Popular Astronomy.

Vol. X No. 8. OCTOBER, 1902. Whole No. 98.

THE PLANET JUPITER.

G. W. HOUGH.

FOR POPULAR ASTRONOMY.

The present opposition of the planet Jupiter is unfavorable for a critical study of the markings seen on the surface, owing to the low altitude of the planet. The *Great Red Spot* which was formerly so conspicuous, has been exceedingly faint for a number of years and would have escaped notice in all telescopes except for the hollow on the equatorial belt directly under the spot. During the present opposition the belt B_6, south appeared in contacts at the following end, probably above the red spot.

The red spot is now a pale flesh color, and the outline has been traced on several nights, so that measures of length, breadth and latitude were possible.

The recent measures indicate that there has been no appreciable change in the size of the object since my first measures in 1879. The adopted length in 1880 was 11″.61 or 37°.2.

The persistence of the hollow in the equatorial belt, directly under the red spot indicates that the belt has the same rotation period as the red spot. As the inner edge of this belt is only one second of arc from the equator of the planet, it shows that the rotation period on Jupiter is not connected by any known law with the latitude.

During the present opposition, the two parts of the equatorial belt north and south of the equator are approximately equal in width. Last year the north became very narrow and faint and in October 1901 it was only one second of arc in width and appeared as a faint line.

There are three faint white spots about two seconds of arc in diameter, situated five seconds of arc north of the equator. These spots have been systematically observed, during the present opposition. The rotation is a little less that given by the red spot. I have observed spots in this latitude during many years, but during some oppositions more are seen. Such was the case in 1901.

For 1878 to 1879, I found the rotation period given by the red spot to be $9^h\ 55^m\ 33^s.7$. It reached its maximum value in 1899, viz., $9^h\ 55^m\ 41.^s68$; since the latter date the spot has had a direct drift with accelerated velocity. For 1900 rotation period was $41^s.50$; 1901, $41^s.01$ and for 1902 the rotation period will probably be 3 seconds less than for 1899.

The motion of the red spot in longitude and latitude is of great interest. During 21 years the retrograde drift increased the rotation period 8 seconds; the maximum drift occurring in 1881, when the change in rotation period between successive oppositions amounted to 1.5 seconds. From observations made by Gledhill on the red spots in 1869-70, I have determined a rotation period $9^h\ 55^m\ 25^s.8$, whence I infer that the cycle in the motion of the red spot is a very long one.

From our present knowledge of motions on the surface of Jupiter it is unsafe to determine rotation period from consecutive observations separated by a number of years.

The red spot has a drift in latitude as well as longitude. The equatorial belt both north and south of the equator, however, has a much greater drift in latitude. Hence I conclude the red spot lies at a lower level than the belt. The great permanency in the red spot leads me to imagine that it is not a simple surface, but has a depth equal to its breadth, in which case its volume would be approximately three times that of the Earth. The superficial density of the surface of the planet Jupiter is probably between 0.4 to 0.5 that of water. The experiment made in recent years in the liquefaction of air and gases, enables us to imagine a medium having the requisite density. The variation in rotation period given by spots and markings on the surface, is best explained by assuming them to lie at different levels in the medium which constitutes the surface of the planet. Over this surface there may be an extensive atmosphere of a density comparable with our own.

The spots, (which sometimes persist for years), from which rotation periods are determined are not in the atmosphere, but in the denser medium which is the visible boundary of the surface of the planet.

YOUNG'S MANUAL OF ASTRONOMY.

WM. W. PAYNE.

FOR POPULAR ASTRONOMY.

In 1888, Professor Charles A. Young published the book now very widely known as Young's General Astronomy. The merit

of that text-book was soon generally recognized, and it rapidly found place in the colleges and scientific schools in all parts of this country, and, we are told, that it was very favorably received abroad wherever the English language was in use, or well enough understood to make it a book of reference.

Ten years later, the advance in astronomy had been so great in almost every important branch of it, that Professor Young thought it necessary to revise his work and bring it to date, which accordingly was done and completed in March, 1898.

These two editions of the General Astronomy were about the same in size, plan, mode of illustration and way of presentation in the class-room. The size was a little under 600 pages, printed in type rather small for a large page, and sometimes so crowded as to give the appearance in parts of an unleaded make-up. We can easily see how this rather unattractive page should result from the author's desire to have each topic and every paragraph so complete in itself, that all should convey the exact state of the science, at the time of writing, in clear and definite language, so carefully chosen, that the student may understand it, and that the professional astronomer may acknowledge it as authority generally without reservation. This important feature of the General Astronomy was well and faithfully carried out to the end of the book in both editions. In the class-room the book has stood without a rival for fifteen years which is one of the strongest things that could be said about any text-book in science in this day of its popularity and wide-spread influence in every walk of life. The second edition of the General Astronomy has now been before the public for nearly five years. In the mean time the feeling in school circles has been growing, so that General Astronomy as a text-book presented a course of study a little too full and too severe for the place it fills, and that students therefore can not grasp the essentials of the branch from it, as a text, in the time that can be allotted to it, in the ordinary courses of the American college or University. For ourselves we were so sure that this General Astronomy was the text we wanted for our classes in Carleton College that we prevailed on the publishers to send us proof sheets enough while the first edition was passing through the press to supply our needs the first time, in 1888. We have used the book in one or the other edition, continuously since that time. We have usually allotted to it a period of 24 or 25 weeks, 4 recitations each week, as a Junior study in the college courses. That time has been a little too short for the best results in our judgment, yet, the arrangement

has answered fairly well, for it has always awakened a strong interest in student classes, for further study of astronomy, and it has carried some forward into practical astronomy, or, reading courses with less of the higher mathematics. We have met one hinderance in our plan heretofore. That is this: It has taken the time so fully to complete the text in the time mentioned above that there has been small opportunity to introduce what is now spoken of in modern phrase as the "laboratory method" of teaching astronomy, for the want of a better name.

Fourteen weeks have been given to the first thirteen chapters with some necessary omissions, and the remaining eleven weeks were sufficient for the following nine chapters to give the study its proper balance in reference to the various branches of research that now belong to astronomy. By this plan we can study the Earth, as a planet, the Moon and the Sun, during the first division of time; and in the second, the planets, comets, meteors, stars and nebulæ. When students could not do more, we have gone so far (although very undesirable) as to allow them to take either division of the study, in time, without the other, thinking it better that such should have some knowledge of a part of the text somewhat thoroughly, than deny them all opportunity, because they were unable to do the full amount required. The plan has worked more favorably than was anticipated in the outset.

For reasons named above and others Professor Young has written another book which he names "Manual of Astronomy." This, he claims, is a text book intermediate between the "Elements of Astronomy" and the "General Astronomy" to which reference has just been made. In this volume the page is a little smaller, the type a trifle larger, and the cuts better than in the editions of General Astronomy. The page is easier for the eye, and the marginal titles to paragraphs are very helpful to student and teacher for reference in using the substance of the text when nothing more is needed. This feature is commended. The number of pages including the appendix and general tables is 591, about the same as those in General Astronomy.

As to the subject matter of the text in the Manual compared with that of General Astronomy, the former contains 20 chapters while the latter has 22. While the same topics are discussed in each almost exactly in the same order, the paragraphs of each are re-written and newly numbered, so that references to these different books must be carefully made to prevent confusion. The first eight chapters in each of the two books cover essentially the same ground. At chapter nine a rearrangement of the matter

begins. This pertains to the Sun and the spectroscope. Three chapters of General Astronomy are reduced to two in the Manual. Also the two chapters on Celestial Mechanics in the former volume, are reduced to one in the latter. The subject of the Tides ends the thirteenth chapter in General Astronomy which reaches to the 318th page. The same topic in the Manual ends the eleventh chapter, on the 310th page. The text pertaining to the planets is rearranged in the Manual; but the matter in chapters following is closely in the same order to the end of both books.

In regard to the exercises at the end of chapters for recitation uses, there is about the same amount of work in each of the two volumes. These exercises are largely the same in both books, but not identical. The Manual contains 174, while General Astronomy has 177. In looking over the exercises in the two books we notice that a few of the results given in the two books differ while the exercises to which they belong, as answers, are identical. We have solved all the exercises in the Manual, and if we are not mistaken a few of the results given by the author are erroneous. This is almost unavoidable if true in the first edition of a new book. Further attention will be given to these apparent errors, and if they are real they will be reported to the author or publishers very soon.

In this hasty review of the Manual, we notice that details in many instances in the General Astronomy have been omitted in the rewriting for the Manual. Teachers will expect this. The main question is, whether or not the author has gone far enough in this direction. If he has erred it probably is on the side of not going far enough in lessening the text to meet the wishes of those who will use the Manual. For our own part it seems as if the author has ranged out just the right level in this new book, and that those who use it as instructors should come to it, if necessary, by the outlay of hard work, on the part of their classes. The tide of student opinion is not now setting favorably to long hours of close, laborious and painstaking labor to acquire knowledge of science for its own sake; but, rather, that all requirements shall be made as easy as possible, and optional generl ally that there may be large opportunity for athletics, society, and a good time generally. Those who have to do with making courses of study for College standing must be constantly on guard to maintain courses of training that shall lay deep and strong foundations for vigorous manhood in youth, the real seedtime of life.

We have thought so well of the Manual of Astronomy that it has been adopted for the classes in Carleton College, and it in use at the present time.

ORIGIN OF A DISTURBED REGION OBSERVED IN THE CORONA OF 1901, MAY 17-18.

C. D. PERRINE.

In my preliminary report* of observations of the Sumatra eclipse by the Crocker expedition from the Lick Observatory, I called attention to an unusual area of disturbance in the corona in the northeast quadrant. At the time of writing that report no observations of the Sun's surface were available from which to investigate the source of this disturbance. Through the courtesy of the Astronomer Royal, Royal Observatory, Greenwich, we have received a set of positives on glass of negatives of the Sun taken at Dehra Dûn, India, on May 17th, 18th, 19th, 20th, 21st, 22d, 26th and 28th, 1901. These photographs are on a large scale, 7½ inches to the Sun's diameter, and furnish the desired observations. They show an intimate connection between activity on the Sun's surface as observed in the Sun-spots and Faculæ and the Corona.

The photographs of May 17th and 18th show no spots or other evidences of activity on any part of the Sun's disc. The absence of spots was noticed before the eclipse at the station in Sumatra. The photograph of May 19th, however, shows a medium sized spot which has just come into view around the east limb. On this date the spot is little more than a line, owing to foreshortening, ½′ in length surrounded by faculæ. On the 20th it is ¾′ in length (*i. e.*, north and south), followed at a distance of ½′ by several small spots forming a close group. On all sides of the group, except the preceding or west side, is a large area of faculæ. The principal spot is compact, with well defined umbra and penumbra, and shows no more changes from day to day than are usually observed in the same period. The group of small spots following, however, shows traces of greater activity, principally growth.

Following are the coördinates of the principal spot deduced from the plates of May 19th and 28th, the longitudes being measured from the center of the disc.

	Greenwich Civil Time.			Longitude.	Latitude.
1901 May 19	3ʰ	30ᵐ	37ˢ	80°.7 East	+ 9°.0
28	7	29	37	46 .7 West	+ 9 .0

From these positions are deduced the following coördinates of the spot at the time of the eclipse in Padang.

	Greenwich Mean Time.			Longitude.	Latitude.
1901 May 17	17ʰ	40ᵐ	37ˢ	93°.8 East	+ 9°.0

* *Lick Observatory Bulletin No. 9.*

From this it will be seen that the spot was on the opposite side of the Sun at the time of the eclipse and within 4° of the limb. Following are the position angles of the spot as projected on the limb, and of the apex of the disturbed area in the Corona observed on the eclipse negatives.

	Position Angle.
Sunspot	60°.2
Apex of Coronal Disturbance	60 .0

During the period of eleven days covered by the photographs only this one group of spots was visible. In this time almost the entire solar surface was under observation.

We see from the above position angles that this region of sunspots occupied the same line of sight as the apex of the disturbed coronal region. While it is true that we have no means of determining the exact position of the coronal disturbance in the line of sight, attention was called to *Bulletin* No. 9 to the probability that its origin was near the Sun's limb. As both sunspot and disturbance are shown to have the same latitude, it can hardly be doubted that this unusual appearance in the corona was in reality immediately above the group of sunspots and faculæ, and that it had its origin in the same disturbance of the Sun's surface. The long, thread-like prominence to the south, seen projected almost tangentially from the Sun's surface, appears likewise to have emanated from the same group of spots and faculæ.

These observations furnish very strong evidenee of the intimate connection of all solar phenomena. Sunspots, faculæ, prominences and corona all seem, in the present case at least, to have had a common origin.

The appearance of this disturbed region in the corona and its undoubted connection with the group of spots on the surface so strongly suggested great activity that an investigation was made as to whether there had been a measurable displacement of any of the coronal masses in this region. The interval of time between photographs of the corona available for this purpose was but little over five minutes, yet if the velocities were large, 50 or 100 miles per second, such motion should be easily detected. The results give no certain indication of motion in the interval. The uncertainties of measurement of these coronal masses is so large, however, that a velocity of 5 or 10 miles per second would not be detected in so short an interval of time. We may conclude that the velocity across the line of sight was less than 20 miles per second.

The interval of one and one-half hours between the times of the eclipse in Mauritius and Padang should render a comparison of negatives secured at these two stations valuable in this connection.

LICK OBSERVATORY, *Bulletin No. 18.*
February 9, 1902.

THE LEONIDS.

WM. H. PICKERING.

FOR POPULAR ASTRONOMY.

In POPULAR ASTRONOMY 1899 VII 523, and 1901 X 8, it was shown that the long expected great meteor shower of November 14 would probably appear in the years 1901 and 1902. This prediction has already been partially verified as far as 1901 is concerned, and it is now hoped that the display in 1902 and perhaps also in 1903 will be finer still.

The shower of 1901 while more distinct throughout the United States than that of preceding years was still not especially remarkable. In Cambridge the maximum number seen by a single observer on the night of November 14, astronomical time, was 60 an hour. While this number together with the few fireballs observed made an interesting display, it still could by no means be called a shower.

In more southerly latitudes however different conditions prevailed, and the meteors appeared with much greater frequency, as will be seen by the following table. In the last two cases only were they expected. Of the other four observers, two, though professing to know little of astronomy, were so much impressed by what they had seen that they voluntarily wrote to the Harvard Observatory describing their observations. The observations of the remaining two were secured through correspondence.

Station.	Lat. °	Long. °	Per hour.
Trinidad, W. I.	10	63	290
Str. Admiral Dewey	26	73	420+
Tuape, Sonora, Mex	30	110	countless
Tucson, Ariz.	32	111	225
Claremont, Calif.	34	118	800
Mt. Lowe Observatory, Calif.	34	118	300

The observations made at Trinidad are taken from a clipping from the *Trinidad Mirror* which says "several persons saw upwards of 290 shooting stars between the hours of three and four

on the morning of the 15th." A careful observer might doubtless have seen more by observing throughout the night and selecting the most favorable hour.

Captain McGrath of the Admiral Dewey states that "in ten minutes between 12 and 1 A. M. the first officer counted over 70, and then they fell so fast you could not keep count." The greatest display was towards the north, between 1 A. M. and 4 A. M.

E. M. Alderman, of Tuape, Mexico, compares the shower to that of Nov. 22, 1892, which he says was magnificent in Mexico. Of the present shower he says "they could not be counted. They were thick as snow flakes in a snow storm more than anything else I can think of." They appeared equally distributed in all points of the compass. No fireballs were seen. The largest appeared about the size of the north star.

Professor G. E. P. Smith of Tucson, Arizona observed with Professor F. Y. Adams, acting president of the University. He says, "At 1:45 I went out on the porch, and the meteors were flying thick and fast. * * * It was a magnificent spectacle, from my point of view, at least. * * * The convergence of the paths was delightful it was so perfect. * * * There was no part of the heavens where they did not appear, but I think the thickest part was south of the zenith." Professor Adams noted one meteor which suddenly changed its course from southwest to northwest, also two meteors going in parallel but opposite directions, and not more than two degrees apart. They saw four large fire balls besides scores of bright meteors that left magnificent trains. The largest fire ball they estimated at magnitude — 5, or about twice as bright as Venus at her brightest.

Professor F. P. Brackett of Pomona College, Claremont, states that the maximum frequency occurred between 4:30 and 5:00 A. M. Apparently four observers were at work at the time, which accounts for the large number of meteors seen. One observer would probably have seen about half as many. He states that "the magnitudes and depth of color both increased with the frequency. Less than a quarter were of first magnitude or higher, most of the time, but more than a quarter during the period of greatest frequency. About half were of third magnitude or less. The prevailing color of those under third magnitude was white, while that of the higher magnitude was orange. A few green and blue ones were seen." Three large fire balls were seen. Of one he says, "At time of bursting it was half as large as the Moon."

An account of Mr. Larkin's observations at the Observatory on Mt. Lowe has already appeared on page 16 of this volume.

It is an interesting fact that all of the stations where these observations were made, save the first, lie nearly along the parallel of 30°. Why the meteors should appear in the greatest numbers in southern latitudes is not at all clear. If they all lay in a very thin plane drawn parallel to their orbit, and if at any moment this plane passed, for instance, through the point occupied by the the steamer Admiral Dewey, at that time, then owing to the motion of the Earth in its orbit, four minutes later that same plane would pass through Cambridge. Yet while as seen from the Admiral Dewey the meteors fell at the rate of 420 or more per hour, as seen from Cambridge, located in the same plane, at practically the same time, less than one-sixth as many were visible. The atmosphere was very clear at Cambridge upon the night in question, and the discrepancy is not explicable in that manner. It is noteworthy that the great showers of former times have mostly been observed not far from the latitude of 30° N.

On the Admiral Dewey it was thought the greatest display was towards the north. At Tuape it was equal in all directions, while at Tuscan the maximum lay towards the south. The latitudes of these places are 26°, 30° and 34°. It is possible that in future observations it may be well to distinguish those meteors which end north of the prime vertical from those which end south of it; but it is doubtful if opinions on this subject not based on numerical values should be entitled to much weight, although the above statements are suggestive.

Should the Earth pass through a dense portion of the meteor swarm this year, as is I think to be expected, it is probable that the most interesting as well as the easiest thing to observe is its intensity. To do this the observer, without taking his eyes off the sky, or making any record whatever, should note the time required to count 10, 20 or 100 leonids. If there are two or more observers they should make independent counts. This should be repeated at different times throughout the night. If the meteors come only occasionally, as large an area of the sky as possible should be covered by each observer, particularly towards the east. If they come faster, the attention should be confined to some smaller area of the sky bounded by four bright stars, and only those meteors should be included in the count that disappear within this area.

Observations of the characteristics of the meteors may be tab-

ulated in the form described in POPULAR ASTRONOMY 1899, VII, 395. Visual observations of the radiant are of little value, but if made at all they should be plotted on a map of large scale such as that given in the *Annals of Harvard College Observatory*, XLI, No. V, and only those meteors included whose paths lie very near the radiant. Photographic observations of the radiant and of the parallax of the meteors are of much more value, but only large meteors lying near the radiant can be photographed. A brief detailed description of fireballs seen to explode, giving accurately the position of the luminous glow left behind at intervals of one or two minutes is much to be desired. Full details of all these matters will be found in the above mentioned articles.

It is probable that the three best ways of indicating the intensity of a meteor shower are, (*a*) By a direct count by a single observer of the total number of leonids seen in some specified time. (*b*) By a statement of the ratio of leonids to non-leonids observed. (*c*) By a count of the number of fireballs seen which leave trails lasting over thirty seconds.

In conclusion it may be said that it is hoped that observers who have been discouraged by the non-appearance of the long expected shower in the United States during the past few years will not now miss the opportunity which may be presented to them in the years 1902 and 1903.

THE LEONIDS OF NOV. 1901 FROM THE REPORTS.

ROBERT B. TABER.

FOR POPULAR ASTRONOMY.

From a comparison of European and American data regarding the meteor shower Leonids of Nov. 1901, it seems evident that the Earth's contact with the meteor stream took place after 12 A. M., Nov. 14, Washington Mean Time, and ceased before 3 P. M., Nov. 15th, being visible only in North America in a curved line S. W. from New England to Southern California, where all trace is lost in the daylight.

The reports from Greece, Rome, France, England and America, agree that no meteoric shower was seen at any earlier date except a few stragglers. Two hours later (14^h) Mr. Upton at Providence is charting short flights in the immediate vicinity of the radiant "20 to the hour;" at 15 A. M. these flights encircle the radiant with a larger radius and with longer paths in increasing number, and the maximum is recorded almost simultan-

eously (unfortunately too vaguely determined) by the Harvard observers at Cambridge, Mr. Upton at Providence, and as far west as Carleton College, as occurring between $15^h\ 30^m$ and $17^h\ 30^m$ in numbers ranging as high as six hundred to the hour.

From the north and east of Boston (upper New England and Canada) no reports are received, owing to the backing up of a storm in the St. Lawrence Valley, and from the lower seaboard United States nothing special is reported, while inland at Fort Worth and on the Pacific coast the shower is very brilliant.

It would almost be possible to state that the shower was vertical at Fort Worth, Texas, about longitude 97 W. from $17^h\ 10^m$ to $17^h\ 20^m$ from the account received, "70 appeared in 10 minutes;"—"with a few exceptions, they all came from a portion of the sky embraced within a circle of about 157′ in diameter." The paths were a notable feature, only a few appearing to go overhead (horizontally?); the remainder descending in nearly vertical paths deflected slightly toward the north and south."

The time of maximum, however, is slightly later than observed at New England, a phenomenon more marked in the report of Mr. Larkin at Echo Mountain, longitude 118°, where the culmination took place between 19^h and 20^h W. M. T., who records 297 flights seen by one observer in an hour; adding a rather unexpected addenda to his report, "the shower being to the southwest." Half way, or nearly so, between these two places in Phœnix, Arizona, longitude 112° W., where the United States observer reports "20 a minute,—in showers,—40 from the perpendicular,—the path of translation due N. W.;" "one in particular resembled a 6-inch globe of cankerous fire," this at 5 A. M. local time," probably 18^h W. M. T. As the difference in time of the display lags behind the Earth's rotation, and the Earth has traversed in her orbit 100,000 miles or more in the interval, the Earth was evidently meeting another part of the stream.

In the northwestern United States at Butte, Montana, recorded by the U. S. Meteorological Bureau and also in Canada through the courtesy of Mr. Stupart of the Meteorological Observatory at Toronto, I was able to obtain a few reports of the visibility of the shower, which was apparently not very striking.

Perhaps in consequence of the hint given in Professor W. H. Pickering's article in POPULAR ASTRONOMY, and for the purpose of ascertaining the southern and western limits of the maximum display, letters were sent to Mr. Bingham at Hawaii, the government officials at Samoa and Guam, and the Observatories at Hong Kong and Tokio, and various steamships on the Pacific,

but with the possible exception of a slight display noted at Tokio nothing unusual was seen;—evidently the shower was lost in northern Pacific and eastern Siberia, or had altogether ceased. It is therefore not surprising that the reports of the next night, Nov. 16, should indicate nothing except a few stragglers lagging half a million miles or so behind the main stream.

With regard to the velocity of the stream there is only one circumstance by which it can be reckoned, viz.: the difference in time of maximum display at Fort Worth and on the Pacific coast, mentioned above. It might be possible to guage its depth by the steady gain in numbers and the growing length of the flights seen at Providence but it is difficult to make out from the reports that any perceptible waning in numbers occurred before the whole was lost in the daybreak, while several large fire balls are reported as visible in the northwest after daylight had obscured the radiant.

With regard to the height of some of the individual meteors, one single coincidence in the reports from Providence and Jamaica Plain, Mass., evidently two notices of the large and easily recognizable meteor, might be used for the basis of calculation. In Mr. Dole's chart quoted in the POPULAR ASTRONOMY, December 1902, there is a flight mapped as occurring at approximately the same time as one recorded at Providence by Mr. Upton. These are as follows:

Mr. Dole, No. 84, R. A. $12^h\ 0^m$, ending R. A. $14^h\ 8^m$; Decl. at beginning 50°, at end 64° 12′.

Mr. Upton, No. 183, R. A. $11^h\ 46^m$, ending R. A. $15^h\ 12^m$; Decl. at beginning 54°, at end 68° 10′. Times $17^h.09$ and $17^m.089$ respectively. No other coincidences are reported.

As regards color one must conclude that this is largely the resultant of atmospheric condition or individual feeling. There is absolutely no identity between the "rouge et brilliant" of M. Eginitis at Athens in the clear sky, and "the prevailing color of white" in a similar atmosphere at Arizona. Mr. Seagrave at Providence in a murkier sky saw his meteors "yellow."

An attempt was made as an interesting study to trace the direction of the drift left by the meteors in the several localities. Too little data is given but what there is, is of interest. In British North America, latitude 50″, the trail floated slowly northward; at Jamaica Plain one drifted northeast 2° in 15 minutes. At Goodsell Observatory after an explosion in Hydra "the long trail was caught near the middle point and driven violently eastward." This is one of several reports which notice

a flexure in the trails perhaps caused by currents at a lower level. On the Pacific Coast the trend is from "Orion to Aldebaran," almost due northeast. Much attention was given to obtaining reports of this phenomena and such scanty returns were received that it is hoped more attention will be given to it this year. Currents that move "slowly" in one direction and "violently" at others at the heights which meteors are supposed to move are an interesting study.

From the preliminary reports the position of the radiant point is practically unchanged. According to the account from Harvard this is given R. A. 10^h 6^m; Decl. 22° 16′. Mr. Upton gives it as R. A. 10^h $2^m.8$; Decl. 21° 19′.

M. Eginitis suggests "une sensible displacement en droite ascension" and Mr. Wilson "the radiant is a point probably rather than a spot 2″ or more in diameter."

Perhaps as interesting a feature as any reported is the peculiar photograph obtained by Mr. Wilson of Goodsell, in which the filaments of the edges of the trail are feathered but contrariwise to the direction of the meteor, as if there might be here a connection with the markings seen on the surface of some meteoric stones—erupting points of molten matter driven off from the surface. In respect to the direction of the filaments this photograph stands alone.

Nearly all of the reports speak of bunched flights, several meteors appearing together, perhaps part of one object or small shoals with no attempt at general distribution in any given area; the general consenus on this point is noticeable.

BURLINGTON, Vt.

ON A GENERAL METHOD OF SUBDIVIDING THE SURFACE OF A SPHERE INTO CONGRUENT PARTS.

H. C. GODDARD.

FOR POPULAR ASTRONOMY.

In *The American Journal of Science*, Vol. XIII, June 1902, Professor David P. Todd, Director of the Amherst College Observatory, outlines a new method of mounting a telescope, which, if successfully carried out, would enable the erection of an instrument approaching 200 feet in focal length.

The feasibility of this scheme will depend in no small measure on the possibility of building a huge steel sphere (say) 100 feet in diameter. Of course the parts of such a sphere must be con-

structed separately and then assembled. To ensure a maximum of accuracy together with a minimum of expense in such construction it is desirable that the parts of the exterior should be congruent. The present discussion then is that of the problem of subdividing the surface of a sphere into congruent parts.

A solution that at once presents itself is the grouping of some convenient number of bi-rectangular triangles about the two poles of the sphere, but the length of the legs of such triangles (quadrants) at once renders this solution impracticable in the case of as large a sphere as we contemplate. Another suggested method, that of making the parts, zones or portions of zones, is open not only to a similar objection but to the further difficulty of lack of congruence among the parts. We must seek some other solution.

Suppose a regular dodecahedron inscribed in a sphere. Then the planes determined by the center of the sphere and the edges (in turn) of the dodecahedron cut arcs on the surface of the sphere dividing it into 12 equal regular spherical pentagons. If the center of each pentagon be connected by arcs of great circles with its vertices, the surface of the sphere is then divided into 60 congruent isosceles triangles whose vertical angles are obviously 72°.

Let A represent a base angle of one of these triangles.

Then $$\frac{2A-108}{90}=\frac{8}{60} \quad \text{or} \quad A=60°$$

To determine b, the base, a, a leg, and p, the altitude of one of these triangles:

Let e represent an edge of the dodecahedron, d a diagonal of one face, and D the diagonal of a regular pentagon each of whose sides is equal to d.

Then $$\frac{e}{d}=\frac{\sin 36°}{\sin 108°}=2\sin 18°$$

Similarly $\frac{d}{D}=2\sin 18°$, or $\frac{e}{D}=\tan\frac{b}{2}=4\sin^2 18°$

An equation which determines b, while a and p are readily found from the equations

$$\sin a=\frac{\sin b\sin A}{\sin B} \quad \text{and} \quad \sin p=\sin a\sin 60°$$

It may be suggested that the use of an isosahedron in place of a dodecahedron, by making the parts smaller, would give a better

solution than the above. This would not be true. The surface of the sphere would in this case also be divided in 60 parts, but their shape would be less convenient than in the other case.

Let us now compute the values of a, b and p first for a unit sphere, from which corresponding values for any radius can readily be found.

$$\tan \frac{b}{2} = 4 \sin^2 18°$$

$$\begin{aligned} \log 4 &= .6020600 \\ \log \sin^2 18° &= 8.9799648 \\ \log \tan \frac{b}{2} &= 9.5820248 \end{aligned}$$

$$b = 41° \ 48' \ 37''.15$$

Length of b on unit sphere

$$\begin{aligned} 41° &= .7155850 \\ 48' &= .0139626 \\ 37'' &= .0001794 \\ .15'' &= .0000007 \\ b &= .7297277 \end{aligned}$$

$$\sin a = \frac{\sin b \sin A}{\sin B}$$

$$\begin{aligned} \log \sin 41° \ 48' \ 37''.15 &= 9.8239088 \\ \log \sin 60° &= 9.9375306 \\ \operatorname{colog} \sin 72° &= .0217937 \\ \log \sin a &= 9.7832331 \end{aligned}$$

$$a = 37° \ 22'' \ 38''.54$$

Length of a on a unit sphere

$$\begin{aligned} 37° &= .6457718 \\ 22' &= .0063995 \\ 38'' &= .0001842 \\ .54'' &= .0000026 \\ a &= .6523581 \end{aligned}$$

$$\sin p = \sin a \sin 60°$$

$$\begin{aligned} \log \sin a &= 9.7832331 \\ \log \sin 60° &= 9.9375306 \\ \log \sin p &= 9.7207637 \end{aligned}$$

$$p = 31° \ 43' \ 2''.91$$

Length of p on a unit sphere

$$\begin{aligned} 31° &= .5410521 \\ 43' &= .0125082 \\ 2'' &= .0000097 \\ .91'' &= .0000044 \\ p &= .5535744 \end{aligned}$$

For a sphere then of 100 feet in diameter

$$\begin{aligned} b &= 36.486385 \text{ feet} \\ a &= 32.617905 \ \text{“} \\ p &= 27.678720 \ \text{“} \end{aligned}$$

If these triangles prove too large in the actual construction, a double series of symmetrical triangles with sides equal to a, p, and $\frac{b}{2}$ may be used, or the triangles may be even further subdi-

vided, if the added expense which will arise from the sacrifice of congruence permits.

The accuracy of our results may be tested by comparison of our original values of a, b and p with the equation

$$2\pi r = 4\,(a + p) + 2b.$$

$$\begin{aligned} 2\,(a + p) &= 2.4118650 \\ b &= \ .7297277 \\ \pi &= 3.1415927 \\ \pi &= 3.1415927 \\ &\overline{0.0000000} \end{aligned}$$

Comparing the computed value of π with the true value shows an exact agreement to seven decimals, or an error of less than 1 part in 30,000,000, or somewhat less than .0001 of an inch in a circumference of over 314 feet.

AMHERST, June 18, 1902.

THE SOURCE AND MAINTENANCE OF SOLAR ENERGY.*

J. MORRISON, M. A., M. D., PH. D.

In the entire domain of human research, there is no subject which has so severely taxed the ingenuity and resources of man as the science of astronomy. To compute the orbits of comets and planets, to calculate their mutual influence on one another so as to be able to predict their positions in the heavens for any given time and to determine the secular variations of the elements of their respective orbits, require the keenest intellect aided by the most refined mathematical analysis. One of the great masters of the science truly said: "Admission to its sanctuary and to all the privileges and feelings of a votary, can only be gained by one means—a sound and profound knowledge of the higher mathematics, the great instrument of all exact enquiry, without which no one can form an independent opinion of his own on any subject which properly falls within its range."

Of all the celestial bodies in the visible heavens the one which first arrested the attention of man and excited his curiosity to learn something pertaining to it, was no doubt, the Sun—the great fountain of heat and light upon which our very existence here depends. This luminary has been radiating into space a prodigious amount of heat and light for an inconceivably long period of time and that too without any visible source of supply. Whence then the cause or source of this prodigious expendi-

* Extracted in part from the author's paper on "Solar Heat," in the Annual Transactions of the Astronomical and Physical Society of Toronto, 1891.

ture of energy? Was the Sun created as we now see it, or was it developed from some pre-existing form of matter? Is it to continue in its present condition for ever, or does it contain within itself the elements of its own destruction? Stupendous questions they are, let us see what answer modern science has to give to them.

There is only one theory which satisfactorily accounts for the solar energy. This theory first proposed by Helmholtz, regards the Sun as a huge globe of incandescent gases slowly contracting under its own gravity by which a portion of its potential energy is being continually converted into molecular energy or heat and light. This is in entire harmony with the nebular hypothesis of the formation of our solar system—a hypothesis first suggested by Sir William Herschell from a careful study of the nebulæ, and subsequently and independently by three of the most profound and learned philosophers that ever lived, viz.: Swedenborg, Kant and Laplace. The last named was a mathematician of extraordinary ability; he investigated the subject from a mathematical standpoint and gave it to the scientific world in its present form. It is now generally known as the Nebular Hypothesis of Laplace and almost universally accepted by astronomers as the true cosmogony not only of our own solar system but also of the visible universe. This hypothesis sets out with the well-founded assumption that the matter composing the Sun and planets once existed as a gaseous nebula extending far beyond the orbit of Neptune and having an exceedingly high temperature; that this gaseous nebula by the combined attraction of similar bodies scattered throughout space and under the action of its own gravity, would not only acquire a motion of translation but would also assume by the mutual attraction of its own particles, an approximately spherical figure with a motion of rotation around an axis passing through its center of gravity; that as the mass cooled by radiating heat into space, contraction of volume would ensue with acceleration of the axial rotation in accordance with well known mathematical principles, and when the acceleration due to the centrifugal force in the equatorial regions, became equal to or greater than that due to gravity, a large portion or segment of vaporous matter would become detached, set free or abandoned which would eventually condense and contract under the mutual action of its own particles into a planet, and that this planet too might under similar circumstances abandon or set free a ring or segment of vaporous matter which would finally condense into a satellite. If the ring or segment of

vaporous matter set free were not of uniform thickness or density it might break up in the process of condensation and form several planets such, for instance, as exist between the orbits of Mars and Jupiter, or if perfectly uniform and homogeneous, it might retain its ring-like character as in the well known rings of Saturn which the hand of Omnipotence appears to have arrested in their career in order to hold them up to the gaze of man to reveal to him the nature of events which happened millions of years before his arrival on the theatre of existence. A repetition of this process would set free one segment after another, each being denser than the preceding until the central glowing Sun would alone remain. Such is a brief statement of the nebular hypothesis according to which the Earth and planets once formed a portion of the Sun. Let us now enquire what evidence there is in the solar system to sustain it. In the first place we find by actual observation that all the planets revolve around the Sun in the same direction and in elliptic orbits of small eccentricity whose planes nearly coincide with the Sun's equator, the slight deviation from circular orbits and the small inclination of the orbits to each other being due chiefly, if not wholly, to their mutual disturbance.

The Sun itself and all the planets, so far as known, revolve on their axes in the same direction and the satellites revolve about their primaries in the same direction as the planet's axial rotation. The planets Uranus and Neptune form an apparent exception to this; their satellites have a retrograde motion around their primaries and the planets themselves probably have a retrograde motion on their axes, but this is by no means inconsistent with the hypothesis, for the direction of the axial rotation of the planet resulting from the segment set free from the central contracting mass, depends on the manner in which the matter is distributed in the segment, that is to say, on the position of its center of gravity with regard to its geometric center.

Moreover, as we shall presently show, if the Sun's mass were expanded until the surface would reach each planet in succession, the period of axial rotation in each position would be exactly equal to the periodic time of the corresponding planet, and so also would the time of rotation of the primary planets expanded in like manner, be equal to the times of revolution of their satellites, thus if the Sun, for instance, were expanded until its surface reached the orbit of Mercury, it would then revolve in 88 days instead of 25 as at present; if expanded until it reached the orbit of Venus, it would revolve in 224 days, and so

on. The only exception to this remarkable relation is found in the inner satellite of Mars whose period is less than one-third of Mars's axial rotation. There are, however, circumstances in the Martian System which are capable of producing the anomalous condition of things which exists there.

The orbit of Mars is and has been for ages, becoming more and more elliptical and therefore the planet is gaining more control over its tiny satellites, and this will continue until the eccentricity of the planet's orbit ceases to increase when the opposite condition of things will begin. The periodic time of the satellites is therefore subject to an inequality of immensely long period depending on the secular variation of the eccentricity of the orbit of Mars. The motion of the satellite may also be retarded by tidal action and for these two reasons its periodic time may be shortened.

The equality in the axial rotation of the Sun and a planet or of a planet and its satellite when the former is expanded until its surface reaches the orbit of the latter, is easily shown as follows: Taking the Sun and Mercury as an example, let R denote Mercury's mean distance from the Sun, F the acceleration due to gravity when the Sun's radius becomes equal to R and T the periodic time, then from the well-known formula

$$F = \frac{4\pi^2 R}{T^2}$$

we have

$$T = 2\pi\sqrt{\frac{R}{F}} \qquad (1)$$

Now gravity on the Sun's surface is 27.65 times that on the Earth's and Mercury's mean distance = 82.916 times the Sun's radius, therefore

$$F = \frac{890.33}{82.916^2} \text{ (feet)}$$

Mercury's mean distance from the Sun = .3871 times the Earth's which we take at 92,790,000 miles.

Therefore $R = 35919000 \times 5280$ (feet).

Substituting these values of F and R in (1) we easily find

$$T = 88.005 \text{ days}$$

which differs less than 52 minutes from the periodic time of Mercury, the slight discrepancy being due to the fact that the numbers used are not absolutely exact.

If we take the Earth and Moon as an example using the recognized values of the quantities that enter into (1) we shall find $T = 27.32224$ days which differs by only 50 seconds from the actual sidereal revolution of the Moon around the Earth.

When the same process is applied to the Sun and each planet in succession, it will be found that the time of the Sun's axial rotation will be identical in every case with the periodic time of the planet.

With regard to the structural features of the planets we can only speak of the Earth and its satellite. The former born of the Sun as a mass of igneous vapor, at once began to cool and contract with consequent accelerated axial rotation. In this gaseous condition, a portion of vapor was set free which subsequently became the Moon, and as the cooling proceeded rapidly the surface soon became too rigid to repeat the process. After the lapse of ages to be counted by millions of years and when only a thin crust of sedimentary rock had been deposited from the then almost universal ocean whose briny waves rolled uninterruptedly over what is now the American continent, one mighty convulsion heaved up in a molten condition, the vast Laurentian chain of mountains in northern Canada. This extensive mass of igneous rock extending in more or less broken or detached masses from the coast of Labrador to the mouth of Mackenzie river, penetrated the comparatively thin overlying strata which now rest against its sides like the sloping roof of a house. The upheaved strata show evidence of having been subjected to a high temperature. The molten rock filled up all the fissures and crevices in the overlying walls, just as melted lead would do if poured on a surface full of holes and cracks. This granitic range of mountains is the oldest portion of our continent; it has withstood all the violent convulsions in subsequent geologic ages and stands today an eloquent witness to the condition of the Earth many ages before the dawn of animal or vegetable life on our planet. We also know from the numerous active volcanos on our globe,—the result of its former gaseous condition—that the subterranean fires are far from being extinguished.

When we turn the telescope on the Moon we find its surface pitted with extinct volcanic craters and cones immensely larger than any now existing on the Earth. The whole visible surface is in a state of chaos which finds no parallel among the roughest portions of the Earth itself. The surface of our satellite shows quite clearly that it was once in a plastic condition. Formed from the *outer* portion of the gaseous mass which

finally became the Earth, the Moon would likely have a lower specific gravity than the parent mass, which we actually find to be the case, the Moon's density being only a trifle more than six-tenths of that of the Earth or about 3.4 that of water. The Moon appears at present to be in a state of absolute quiescence. A profound silence reigns over its desolate and rugged surface. The atmosphere and water which doubtless once existed there, have ages ago been frozen as solid as the rocks themselves.

When we direct the telescope and spectroscope to the sidereal heavens we find vast gaseous nebulæ scattered in all directions throughout space. These generally show a nucleus or center of condensation with frequently detached masses around the circumference, all of which would appear to indicate the development of a new sun and its system of planets.

If the Earth once constituted a portion of the solar mass, it should contain the same chemical elements as the Sun, and this has been abundantly verified by the spectroscope by which the more common elements such as hydrogen, calcium, magnesium, iron, etc., to the number of about 20, have been found in a gaseous condition on the solar surface. Subsequent researches will doubtless reveal many more.

Now it may be asked, can all these dynamical and structural features be the result of chance? Do not the planetary and solar movements, the physical constitution of our own Earth and its satellite and the numerous gaseous nebulæ in the sidereal heavens, impress our minds with a profound conviction that they have had a common origin and a common history? The Omnipotent Creator appears to have evolved the solar system according to a method and by the operation of laws established by Himself just as He has evolved the giant oaks of the forest from the tiny acorns. Does not then the nebular hypothesis of Laplace emerge from the region of speculation and rise almost, if not entirely, to the dignity of a demonstration?

Assuming now that the Sun has attained his present dimensions by the slow contraction of the original gaseous nebula in accordance with the nebular hypothesis, we shall now enquire how much the Sun's volume must contract in a year in order to generate the amount of heat and light radiated in the same interval.

Heat is measured by an arbitrary unit called a calorie which is defined to be the amount of heat required to raise one kilogram of water one degree centigrade. From numerous carefully conducted experiments, it has been shown that a square metre of the

Earth's surface receives from the Sun when his rays are vertical, from 25 to 30 calorics per minute due allowance being made for atmospheric absorption which amounts to about thirty per cent of the whole. This quantity, viz., twenty-five calorics per square metre per minute has been adopted as the unit in estimating the quantity of solar heat and is called the "Solar Constant." We prefer, however, to express this in the English system of weights and measures.

Denoting the caloric as above defined by C and the quantity of heat required to raise one pound of water through one degree Fah. by J, we have

C = quantity of heat to raise 1 kilogram of water 1° Centigrade
= " " " " " 2.20462 lbs " " 1°.8 Fah.

or $\dfrac{C}{1.8 \times 2.20462}$ = quantity to raise 1 lb. of water 1° Fah.

$= J$

whence $C = 3.968316\, J$

Again, 1 square metre receives 25 C in 1 minute,

or 10.764 square feet receive 25 C in 60 seconds,

or 1 square foot receives $\dfrac{25C}{10.764 \times 60}$ in 1 second,

or 1 square foot receives $\dfrac{25 \times 3.968316\, J}{10.764 \times 60}$ in 1 second,

or 1 square foot receives .15361 J in 1 second,

that is one square foot of surface receives .15361 thermal units in one second when the rays fall vertically.

Quantity of Heat Radiated.

Let Δ denote the Earth's distance from the Sun expressed in feet then the surface of a sphere whose radius is Δ is $4\pi\Delta^2$ and every square foot of this receives .15361 thermal units in one second, therefore the whole quantity of heat radiated in one second is $.61444\pi\Delta^2$ thermal units.

The Earth and other planets receive only an infinitesimal portion of this, what becomes of the remainder we know not—it is one of the unsolved problems of astronomy.

Quantity of Heat Generated.

In the process of contraction a particle on the Sun's surface falls towards the center by an amount equal to the diminution of the radius, but the particles below the surface fall a shorter dis-

tance by reason of the diminished force of gravity which within the sphere varies directly as the distance from the centre. The whole mass of the Sun then falls gradually towards the center, but the amount of heat generated under such movement will evidently be the same as if the mass had fallen freely through the same distance and then been suddenly stopped.

Let R, denote the Sun's radius,
r, the radius of any point P, below the surface,
x, the linear contraction of the radius R,
x', the linear contraction of the radius r,
G, the force of gravity at the Sun's surface,
g, the force of gravity at the point P,
and δ, the Sun's mean density.

Then we shall have the following relations:

$$\frac{x}{x'} = \frac{R}{r} \quad \text{and} \quad \frac{G}{g} = \frac{R}{r}$$

whence
$$gx' = Gx\frac{r^2}{R^2} \tag{2}$$

The volume of a thin concentric shell whose radius is r and thickness dr, is $4\pi r^2 dr$ and its weight is $4\pi g\delta r^2 dr$, and since every unit of this falls x' feet in one second, the kinetic energy generated in one second by the shell alone is

$$4\pi g x' \delta r^2 dr.$$

Eliminating gx' by (2) and integrating we have

$$\frac{4\pi\delta Gx}{R^2}\int_0^R r^4 dr = \frac{4}{5}\pi\delta GxR^3 \tag{3}$$

which is the kinetic energy developed by the fall of the weight $\frac{4}{5}\pi\delta GR^3$ through x feet, or by the fall of the weight $\frac{4}{5}\frac{\pi\delta GxR^3}{772}$ through a height of 772 feet, but one pound of matter falling freely 772 feet develops heat enough to raise one pound of water through one degree Fah. or one thermal unit, therefore the number of thermal units generated in one second by the entire mass is $\frac{4}{5}\frac{\pi\delta GxR^3}{772}$, and since the quantity of heat generated is assumed to be equal to that radiated, we shall have

$$\frac{4}{5}\frac{\pi\delta GxR^3}{722} = .61444\pi\Delta^2$$

whence
$$x = \frac{592.9346\Delta^2}{\delta GR^3} \tag{4}$$

The mean density of the Sun is about 1.39 that of water, one cubic foot of which weighs 62.424 lbs., and the intensity of gravity at the Sun's surface is 27.65 times greater than at the Earth's surface, therefore we have

$$\begin{aligned}\delta G &= 27.65 \times 1.39 \times 62.424 \\ &= 2399.1728 \text{ lbs.}\end{aligned}$$

Taking the mean solar parallax at 8″.81, the Sun's mean distance is 92,790,000 miles $= \Delta$, and the mean angular semidiameter of the Sun is 16′ 2″ $= s$, then $R = \Delta \sin s$. Substituting these values of δG, Δ and R in (4) and expressing Δ and R in feet we have

$$\begin{aligned}x &= \frac{592.9346\Delta^2}{2399.1728\Delta^3 \sin^3 s} \\ &= \frac{1}{4.0462688 \times 92790000 \times 5280 \sin^3 s} \qquad (5) \\ &= .00000498385 \text{ feet in one second or } 157.281084\end{aligned}$$

feet in a sidereal year or 29.788 miles in one thousand years.

Now 450 miles of the Sun's diameter subtends at the Earth an angle of 1″ and therefore it would require over 7550 years for the Sun's angular diameter to be reduced by one second of arc which is about the smallest angle that can be accurately measured on the the solar disk. Nearly eight thousand years must elapse before this result can be verified by direct observation, but that it will be so verified there is not the shadow of a doubt. This result, however, can only be regarded as an approximation and perhaps a rough one at that, but however far it may be from the truth it shows that the nebular hypothesis not only accounts satisfactorily for the formation of the solar system but also for the source and maintenance of the solar energy.

Assuming then that the nebular hypothesis is true—and no good reason has been shown or can be shown for rejecting it—the present condition of things can not last for ever. A time must come in the far distant future—how many millions of years it is impossible to say—when the Sun will cease to radiate sufficient heat and light to maintain animal and vegetable life on the Earth.

At the present rate of contraction, the Sun's apparent angular diameter will attain about three-fourths of its present value in about three or four millions of years and the density will then be fully double of what it now is. The prodigious radiation of heat during this long period and under such changed circumstances,

will probably reduce the temperature to such a degree that a liquid or semi-liquid crust will be formed on the surface when a rapid decline in the radiation of heat and light must necessarily take place, but many ages before this the human race will have disappeared from the face of the Earth. Owing to the reduction of temperature the productiveness of the Earth will gradually decline; it will no longer be able to support its populations which will gradually decrease in numbers and finally become extinct.

Owing to the great reduction of heat, the light of the Sun must necessarily change. The rays of the blue end of the solar spectrum appear to predominate at present, which indicates a high degree of molecular activity but the time will come when the Sun will emit a greenish light to be succeeded by yellow and orange and will finally throw a dull red glare over the dying embers of the solar system. The Sun must ultimately become a dark globe unless some great catastrophe befall it similar to that of Nova Persei, in which case it may be restored to its original gaseous condition and endowed with all its pristine energy. Nearly all the variable stars give a red light which would appear to indicate that they have passed their stage of maximum activity and are now approaching that of extinction.

The benign influence of the Sun is felt throughout the entire solar system into which it infuses life, energy and activity. By its genial warmth and marvellous light it clothes our hills and valleys in their glorious garb of green so pleasing to our eyes, and by the action of its chemical rays it gradually transforms that same green mantle into the golden tints of autumn.

It paints the maiden's cheeks in their rosy tints and the evening clouds in their gorgeous hues. It sets in motion the gentle zephyr that cools our heated brow on a hot summer day and it also calls into activity the awful hurricane and cyclone which carry death and destruction in their paths. It releases from their icy fetters the tiny streams that trickle down the sides of snow-clad mountains to form the source of the mighty rivers that irrigate our plains and facilitate commerce and international communication. It distils from the surface of our oceans and lakes vast volumes of aqueous vapor which ascend into the atmosphere to form clouds to temper the solar heat, and by their condensation to produce the refreshing showers of rain to purify our atmosphere, to fertilize our fields, to nourish the kindly fruits of the Earth for our sustenance, to raise every fainting flower and to revive all animated nature. In remote geologic ages the solar energy was stored away in those gigantic forests which

ultimately became beds of coal which we now exhume to warm and light our homes, to drive our mills and factories, to propel our locomotives and ships and to contribute to our comfort in a thousand ways. In short there is not on the surface of our planet a form or phase of energy which is not derived directly or indirectly from the glorious orb of day.

WASHINGTON, D. C.,
Sept. 8, 1902.

LUNAR PHENOMENA IN OCTOBER.

WILLIAM H. PICKERING.

FOR POPULAR ASTRONOMY.

An interesting letter has recently been received by me from Mr. G. S. Jones, of Philadelphia, describing a brilliant star-like point that he observed on the dark side of the Moon's terminator on August 12^d $7^h.5$ E. S. T. It was the third or fourth magnitude, and under a high power "showed a perfectly round spurious disk and at least one well marked interference ring." The instrument used was a 6.25-inch reflector, power 250. In the course of a couple of hours, as the terminator advanced towards it, it resolved itself into a very brilliant spot. It apparently coincided in position with the little crater known as Lambert, but the exact identification was uncertain on account of clouds that later obscured the Moon. Lambert it may be noted is one of the few craters upon the Moon whose interior and walls both are dark.

In 1789 Schroeter saw a similar star-like object near the foot of Mount Blanc, which he recorded as of the fifth magnitude. The same object apparently was seen by Grover in 1865. Of the peak Γ situated near Lambert and to the west of it, Niesen remarks "Occasionally this peak glitters on the terminator in a very striking manner, and then appears fully 8° bright, though usually not more than 5½°." This peak was identified by Mr. Jones during his observation by means of a drawing, so that his star-like point does not coincide with it. A short distance on the other side of Lambert lies Lahire. Of it Nieson says "This mountain was seen by Schroeter under very different conditions of illumination so brilliant as to glitter with rays like a star;" again, "Webb has seen it on the terminator glittering and radiating as described by Schroeter." Since Mr. Jones' star cannot be identified with either of these mountains, it appears that there

are least three of these curious objects in this immediate vicinity. Since, moreover, his star showed a diffraction ring, which has never before been observed as far as I am aware in such a position, and since his aperture was only 6.25 inches, I do not think the object can have been fainter than the third magnitude. It may be noted in this connection that such is the brightness of the Moon that even a first magnitude star in this position would probably be invisible to the naked eye.

As Mr. Jones suggests, the appearance is probably due to a flat polished surface of ice reflecting the Sun like a mirror, as the snow sometimes does on the roof of a house. Since the three objects are all between 26° and 28° north latitude, it is evident that their surfaces cannot be level. A similar appearance was observed on a mountain range in the southern snow cap of Mars at the Lowell Observatory in 1894, and ascribed at the time to a similar cause.

On October 10^d $7^h.5$ E. S. T , the lunar terminator will occupy practically the same position that it did during Mr. Jones' observation. Unfortunately the libration will be quite different, especially in longitude. It is therefore doubtful if the phenomenon is exactly repeated, still if any small bright object can be found in Lambert at that time that later disappears, the observation will be of interest. At the time of Mr. Jones' observation August 12, the co-longitude of the lunar termination was 18°, the libration + 1°.8 in latitude, and — 4°.4 in longitude, and the value of *C* 9°.8. *See Crommelin's Ephemeris, Monthly Notices*, 1901, LXII, 91.

On October 16 there will be a total eclipse of the Moon, central near midnight in the eastern portions ot the United States. This will furnish an excellent opportunity to repeat the observations on Linné described in POPULAR ASTRONOMY 1900, VIII, 57. On that occasion the north and south diameter of the white area was found to be appreciably larger for half an hour after the spot reappeared from the shadow, than it was either earlier or later in the evening. This phenomenon was ascribed to an extension of the deposit of hoar-frost during totality. Further observations are needed to confirm this result, and since the object is always a hazy one, whose diameter varies from day to day with the altitude of the Sun as seen from the Moon, it is desirable that the observer should familiarize himself with it by means of measures made upon two or three days preceding that of the eclipse.

HARVARD COLLEGE OBSERVATORY,
September 10, 1902.

THE VALUE OF THE GRAVITATION CONSTANT.

G. K. BURGESS.

In 1885 Harkness* made a calculation by the method of least squares of the value of the gravitation constant, but the best experimental work has been done since then, and it seems desirable today to deduce from all the data at hand the most probable value of the gravitation constant and its analogue the mean density of the Earth. Boys, in his report to the Paris Congress, 1900, has made a critical study of the various methods, but does not suggest a best value for the constants. To do this last is our object.

The gravitation constant is the quantity K in the formula which expresses the Newtonian law of attraction:

$$F = K\frac{mm'}{r^2}.$$

This constant is related to the expression for the mean density of the Earth, approximately as follows:

$$\Delta = \frac{3}{4}\cdot\frac{g}{Kr}$$

in which g is the acceleration due to gravity of a mass at the surface of the Earth whose radius is r and mean density is Δ.

We may classify the methods for measuring K and Δ in two categories: Astronomical or geodetic, as those employing the plumb-line, the pendulum and any method depending upon the variation of the acceleration of gravity; and the methods employing some form of the torsion balance, the chemical balance and the metronome pendulum.

For the first, use is made of a considerable extent of ground and includes a geological survey of the rocks in the neighborhood. In the second, measurements are made in the laboratory upon known masses and distances.

The oldest measures belong, in spite of the fact that the work of Cavendish dates from the eighteenth century, to the first category. In this first group quantities are dealt with which have always been very uncertain—uncertainties of the same order as those involving the investigation of the density of the outer strata of the Earth.

In the second category, all the accuracy that may be obtained

* Harkness, Append. III., Washington Obs., 1885. Bibliography in Recherches sur la Constante de Gravitation, Burgess, 1901; pub. by Hermann, Paris.

is subordinate to measurements of very small length and sometimes of time, and to adjustments for symmetry.

Let us examine these various methods for the determination of our constants. We will first consider the observations based on astronomical or geodetic methods. It was Bouguer who first tried to establish such a determination by measuring the attraction of a mountain. Maskelyne and Hutton in 1775 were the first to obtain results by this method.

Two processes exist for the determination of the attraction of a mountain: In the first, the attraction of the mountain on a plumb-line is measured by joining a point on the north to a point on the south by triangulation. The latitudes of these points are determined astronomically, and their positions, compared to those furnished by the triangulation, give the value of the deviation of the plumb-line.

The second process, as does the first, requires a study of the rocks that compose the mountain and a determination of the diminution of the acceleration of gravity at the summit of the mountain as compared with measurements made at the base reduced to sea level.

This same principle of the variation of the acceleration due to gravity is applicable to measurements made in mines, as was first done by Airy.

Another method depending upon the attraction of great terrestrial masses was proposed by Thomson and Tait. This would be to measure the variation of g at the seashore where there are very high tides as in the bay of Fundy.

Coming to what we may call the indoor methods, Wilsing made use of a metronome pendulum of very long period, swinging at first alone and then beside a very heavy mass. This method is susceptible of more accuracy than is given by the ordinary use of a pendulum.

Such scientists as Von Jolly, Poynting, Koenig, Richarz and Menzel have employed the chemical balance for this determination. Von Jolly's apparatus was installed in a tower 21 meters high. He measured the change in weight produced in a spherical mass of mercury of 5 kg. by a lead mass of 5,775 kg. placed directly beneath, while another 5 kg. mass remained in the other balance pan at the top of the tower. This method necessitates a knowledge of the variation of the acceleration of gravity for the place of observation—a variation that is never in accord with the theoretical calculations—also changes of temperature played a most important vitiating rôle.

Poynting made two series of determinations of which the second is an improvement over the first. He had a long-arm balance of considerable sensibility which he further increased by the use of a mirror suspended by two threads: the one fixed, the other attached to the arm of the balance. The masses could be hung at two levels to eliminate the attraction of the balance-arm. The attracting mass was placed below the balance on a turn-table which a fourth smaller mass kept from tilting. The suspended masses weighed 21.5 kg. and the attracting mass 153 kg. Two independent determinations made with the same apparatus gave him 5.52 and 5.46 for Δ. The balance-beam rested continuously upon its knife-edge during a series; the temperature variations were a minimum.

Recently, Richarz and Krigar-Menzel have used the chemical balance in the following way: A rectangular mass of lead of 100,000 kg. carried a balance to which could be suspended, either above or below the lead mass, mercury spheres of 1 kg. hung from the balance-beam which was 23 cm. long with a half-period of ¾ min. It was necessary as in Jolly's case to determine the variations of g with the height, both with and without the presence of the lead mass. The change in weight was determined by displacing the mercury spheres alternately from the upper to the lower positions. To obtain a precision of 0.1 per cent it would be necessary to measure a weight of 0.0001 mg.

The order of magnitude of the quantities measured was 1 mg. The greatest pains were taken to obviate suspected sources of error, but the balance was raised and lowered from its knife-edge during a series.

A balance that turns about a vertical axis may be rendered more sensible than a balance oscillating about a horizontal axis. It is for this reason that Cavendish's balance and its various modifications have been the most often used to determine the gravitation constant. This method possesses still another advantage: that of giving us the value of this constant independently of the local value of the acceleration of gravity. Besides here we do not have to guard against dust whose effects may be appreciable in Richarz's method. In the torsion method, the most serious sources of error arise from uncertainties caused by variations of temperature which give rise to convection currents, and to the imperfect elasticity of the suspension wire.

The classic set-up for the method is the following: Two small masses are hung from the extremities of a horizontal beam supported by as fine a wire as possible. Two heavy masses attract

the others. The deflection produced in the zero positon of the movable system by a known change in position of the heavy masses is sought. This angle, the geometrical data, the time of oscillation, the moment of inertia and the value of g being known Δ and k may be computed.

Cavendish made his investigations in 1793 and although Baily, with a large subsidy from the British Government, took up the matter in 1841, the result of his two thousand observations is of much less importance than that of Cavendish, who showed the important rôle played by small changes of temperature in the apparatus and its vicinity. In 1873 Cornu and Baille determined the influences of a resisting medium on a torsion balance and showed that the resistance of the air for very small velocities is rigorously proportional to the velocity. These scientists also showed the advantage in reducing the dimensions of the apparatus, that by this its sensibility was in nowise reduced, rendering also its behavior more constant. They were the first to make use of a chronograph for measurements of this nature.

Boys, who commenced his measurements in 1889, made an apparatus of almost microscopic dimensions. Cavendish's balance-arm was 180 cm. long, Cornu's 50 cm., but Boys' only 2.3 cm. The masses were proportionally reduced. In the Cavendish apparatus the attracting spheres were 30 cm. in diameter, while those in Boys' apparatus were but 6 cm. in diameter. His maximum deflection was about one degree, the couple to be measured 200 times as small as that of Cornu's and 1,500 times as small as Cavendish's. It is probable that Boys went too far with such very small dimensions, for it may happen that the errors arising from the geometrical measurements and from want of symmetry play a considerable part. In discovering how to make quartz fibers and their elastic properties he acquired precious auxiliaries, the non-homogeneity of the suspension wire having always been a source of great uncertainty. In order to increase still more the sensitiveness of the system, Boys placed his two pairs of spheres at different levels, thus avoiding the attraction in opposite sense of each of the large upon the more distant small sphere. An advantage gained by the smallness of dimensions in this apparatus was to render minimum the perturbations produced by air currents due to convection or temperature changes.

Doctor Carl Braun is the first who has succeeded in operating his apparatus in vacuo. The attracting masses are of mercury of 900 grams each, placed at a distance of 40 cm. The attracted masses weigh 54 grams and are attached at either end of an

aluminium arm of 24.6 cm. length. To obtain the results already published he made use of a brass wire which he is at present replacing by quartz to continue his researches, in which he operates by two methods: the classic method of deflection and the method of oscillation, which consists in noting the time of oscillation for the positions of maximum and minimum attraction of the heavy masses. Instead of using a scale and telescope placed at several meters from the apparatus, his telescope is but a few decimeters distant. The measurements of deflection are made by means of a scale of a few centimeters length and an ocular, and the luminous beam undergoes several reflections and refractions which may introduce indeterminable errors of considerable size.

The balance of Eötvös can be turned horizontally as a whole and the measurements of the time of oscillation for the maximum and minimum positions between two quadrangular pillars which are the attracting masses are then taken. The sensibility of this apparatus is such that it is capable of detecting the variations in the horizontal component of gravity at a point distant only 50 cm. from another. A quartz fiber is not used.

Summary of Experimental Results.

1. *Astronomical and geodetic methods.*

Observer.	Station.	Result.	Date.
Maskelyne and Hutton	Schehallen, Scotland	4.71 and 4.45	1771
Carlini	Mt. Cenis, Italy	4.77, 4.95, 4.84	1824
Airy	Harton, England	6.57 and 5.48	1855
James and Clarke	Arthur's Seat, Scotland	5.32	1855
Pechmann	Gerold, Alps	6.13	1865
Mendenhall	Fuji-yama, Japan	5.77	1880
Sterneck	Pibram, Bohemia	4.77	1883
	Freiberg, Saxony	6.77	1885
Preston	Haleakala, S. I.	5.57	1887
	Mauna Kea	5.13	1892

Mean: 5.60 ± 0.13, $p = 0$.

(Without Sterneck's second value).

2. *Wilsing's pendulum* 5.5579 ± 0.018, $p = 1$ (1889).

3. *Observations with chemical balance.*

Observer.	Result.	Date.
V. Jolly	5.692 ± 0.068	1881
Poynting	$5.493 [\pm 0.03]$	1891
Richarz and Krigar-Menzel	5.505 ± 0.009	1898

Mean: 5.507 ± 0.014, $p = 2$.

4.—*Observations with torsion balance.*

Observer.	Result.	Date.
Cavendish	5.45 [± 0.05]	1798
Reich	{ 5.49 ± 0.023	1837
	{ 5.583 ± 0.015	1852
Baily	{ 5.67 or 5.55	1843
	{[5.55 ± 0.05]	
Cornu and Baille	{ 5.50 and 5.56	1878
	{[5.54 ± 0.02]	
Boys	{ 5.5270 ± 0.0019	1895
	{[5.5226 ± 0.0041]	
Braun	5.5273 ± 0.0012	1896
Eötvös	5.53 [± 0.010]	1896

Mean: 5.5243 ± 0.0009, $p = 300$.

The mean, deduced from all these series, treated by the method of least squares, is:

$$\Delta = 5.5247 \pm 0.0013.*$$

The corresponding value of the gravitation constant is:

$$K = 666.07 \,.\, 10^{-10} \overline{\text{cm.}^3/\text{gr. sec.}^2} \pm 0.16 \,.\, 10^{-10}.$$

Let us consider the above series:

Series I.—There is great uncertainty in the value found for the mean density by these methods for reasons already indicated, and the mean of all these measurements has a probable error of 4 per cent. In fact, it would seem futile to attempt exact measurements by such methods, by reason of the uncertainty of quantities, such as the density of mountains and the superficial strata of the Earth, which enter into the equations. Also, no great progress has been made here since the first attempts.

Series III.—There are but three determinations by this method but their respective weights increase greatly from the first to the last. It is probable that the figure found by Richarz and Krigar-Menzel is as accurate as can be hoped to be obtained by our chemical balances of today. As in the first series, the problem is complicated by the variation of g with elevation. Richarz found a difference of 0.5 per cent, in this variation for his two determinations at an interval of two years—introducing a like uncertainty into his results.

Series IV.—We have here a considerable number of results which are closely grouped about the mean. The quantities in brackets are the estimated values and probable errors. Baily made a constant error in the interpretation of his results; the corrected value is given. In Boys' case the value in brackets is the result deduced from all of his series and not from the four highest

* The probable error is indicated.

as he deduced it. The most recent observations by this method—those of Boys and Braun—are practically identical with each other and with the mean deduced from all observations.

If we consider the results of the last two series for the last twelve years, we see that the chemical balance gives a value 0.5 per cent. lower than that obtained by the torsion balance for the mean density. Nevertheless, taking all things into account I think it may safely be said that we know the mean density of the Earth and the gravitation constant to well within 0.001 part of their respective values, as indicated above.

If the weight assigned to the torsion-balance determinations be reduced from 300 to 3, we have:

1.	Wilsing's pendulum	$\Delta = 5.5579$	$p = 1$
2.	Chemical balance	5.507	$p = 2$
3.	Torsion balance	5.5243	$p = 3$
	Mean	$\Delta = 5.5241$	

This result is identical with the previous one.

It would seem desirable to make a new determination by Wilsing's method.

UNIVERSITY OF CALIFORNIA,
February, 1902.

SOME NEW ASTRONOMICAL INSTRUMENTS.

FRANK SCHLESINGER.

I. The Registering Micrometer.—The greatest obstacle in the way of more accurate determinations of right ascensions is the observer's personal equation, which causes him to estimate the time of a star's transit always too early or always too late. Were the personal equation constant for each observer for a reasonably long period, things would not be so bad; but it has been known to vary in the course of a single night, besides depending upon the brightness of the observed object, and even upon the steadiness of the atmosphere. Repsold, the head of the famous firm of instrument-makers of that name, has constructed an instrument, called the registering micrometer, which is intended to do away entirely with personal equation. Instead of the ordinary reticule seen in the eye-piece of a transit instrument, the registering micrometer has a single movable thread, which the observer sets upon the star as soon as it appears; and he keeps the image constantly bisected (during the minute or so that it takes

the star to traverse the field) by steadily turning the screw to which the thread is attached. This screw is so constructed that it automatically records a signal upon a chronograph sheet every time it completes a turn, or even more often, if desired.

This micrometer has been tested by Dr. Albrecht and three others of the staff of the Potsdam Geodetic Institute. The differences of personal equation between each pair of these observers were first determined with the ordinary reticule and then with the new micrometer, with these results:

DIFFERENCES OF PERSONAL EQUATIONS.

	With ordinary reticule.	With registering micrometer.
	s	s
Albrecht minus Borass	— 0.108	— 0.004
Albrecht " Galle	— 0.314	— 0.035
Albrecht " Schnauder	— 0.184	— 0.027
Borass " Galle	— 0.225	+ 0.013
Borass " Schnauder	— 0.086	— 0.023
Galle " Schnauder	+ 0.109	— 0.006

It will thus be seen that the personal equation is g otten rid of, or at least is nearly the same for all observers. Dr. Albrecht also finds that the instrumental constants (collimation, flexure, etc.) can be more accurately determined with the new micrometer. In conjunction with Dr. Borass he has determined the difference of longitude between Potsdam and Bucharest, and between Potsdam and the Poulkova Observatory. The results show surprisingly small probable errors.

A still further improvement has been made by providing the micrometer with clockwork to move the threads across the field. As the rates with which stars apparently move are different in various parts of the sky (those nearest the equator moving fastest), the clockwork must be adjustable to the declination of the star. The observer bisects the image as soon as it appears and then sets the clockwork going. The thread will now approximately bisect the image during the whole of its transit. It will not do so exactly, because of the unsteadiness of the atmosphere and because of irregularities in the clockwork itself; these the observer must counteract by hand, turning the screw slightly to and fro. This arrangement has been tried by the astronomers at Königsberg, by whom also it was devised. As might be expected, the addition of the clockwork has added to the already great accuracy of the instrument.

It is interesting to note that the registering micrometer with

clockwork was proposed as early as 1865 by Carl Braun, of Kalocsa, Hungary, but his paper on the subject does not seem to have met with the appreciation it deserved.

II. A New Shelter for Meridian Instruments.—The registering micrometer is intended to improve right ascensions. It is in place here to mention a simple expedient by which it is hoped to get better determinations of the declinations of stars. The importance of the temperature of the observing room is attracting more and more attention,* and the desirability of open air observations has been pointed out. Three years ago, with this in view, the International Latitude Observatories (in latitude 39° 8′) were built with roofs which could be rolled entirely away from the instruments beneath. In erecting the new meridian circle at the Cape of Good Hope, Dr. Gill has gone even further. The shelter for the instrument is of steel, and is built of two entirely separate parts, which meet in the meridian. When ready to observe, the two halves are rolled away from each other (the one east and the other west) by means of a small electric motor, and the instrument is thus left actually in the open air.

III. Automatic Heating Apparatus for Spectrographs.—Another example in which temperature is of the first importance is afforded by spectroscopic observations for motion in the line of sight. The photographic exposures for this purpose sometimes last an hour or more. If the temperature of the prisms changes much in this time, their indexes of refraction also change and consequently the lines in the spectrum become broad and ill-defined. The first to use artificial means to maintain the prisms at a constant temperature was Deslandres, of the Meudon Observatory. He enclosed the whole prism-box in a tight compartment and allowed water at a constant temperature to flow through it. A much less cumbersome device was that of Lord, of the McMillin Observatory, Columbus, who was the first to use electric heating. He encased the spectroscope in a wooden box, and so placed a thermometer that its bulb was near the prisms, while its graduated tube projected not only outside of the metallic box containing the prisms, but also outside the outer wooden box. It was not necessary, therefore, to remove the latter in order to read the temperature at the prisms. The wooden box was lined with a quantity of German-silver wire. As this substance is not a good conductor of electricity, it will become slightly heated when a mild current is passed through it.

* See for example, Dr. Townley's review of Bauschinger's "Untersuchungen über die astronomische refraction," No. 71 of these *Publications*.

The observer watches the projecting thermometer, and if the temperature falls, he turns on the current long enough to bring it back to its original point. A simple improvement upon this arrangement was made by Campbell. The bulb of the thermometer was placed outside of the prism box, but still within the wooden box. By controlling the temperature in this region, the prisms themselves will really have a more even temperature than in the former arrangement. The idea of providing a thermostat which would automatically control the temperature of the prisms seems to have suggested itself to several observers. Dr. Hartmann has carried out this idea in connection with the new telescope at Potsdam in an especially ingenious manner. Into the open end of a thermometer tube is inserted a platinum wire so arranged that its end may be set at any desired reading of the temperature scale. Another platinum wire is set permanently into the bulb of the thermometer and is in contact with the mercury. The free ends of these two platinum wires are connected with the opposite poles of a weak electric battery, the circuit also including a small electric magnet. It is clear that there will be a complete circuit only so long as the mercury in the tube remains in contact with the inserted wire,—that is, so long as the temperature does not fall beyond a certain point. When the circuit is broken the magnet releases its armature, and this in turn completes the circuit of the heating current. Thus, as soon as the temperature near the prisms falls, it is at once raised to its original point by the automatic action of the thermostat. Two independent heaters are used,—one on each end of the prism box, —in order to insure a perfectly uniform temperature of the air surrounding the prisms. The whole spectroscope, including the two thermostats and the two heaters, is, of course, inclosed in a tight wooden box.

IV. Wright's Apparatus for Photographing the Comparison Spectrum.—The instrument we have just described enables the observer to devote almost all his attention and time to accurate guiding of the telescope. The only interruptions that need be made are for the purpose of photographing a comparison-spectrum (usually the spark-spectrum of iron) in immediate juxtaposition with the star's spectrum. It is generally regarded as desirable to photograph the comparison-spectrum once or twice after the exposure for the star has begun and once or twice before it is quite finished. To do this by the old methods, the observer must stop the exposure on the star, put the sparking apparatus into position, expose the plate to the spark, remove the sparking

apparatus and resume the exposure on the star. All this takes considerable time and may possibly disturb the adjustment of the spectroscope. Mr. Wright, of the Lick Observatory, has devised a neat method for introducing the spark-spectrum without stopping the exposure on the star. The middle part of the spectroscope slit is used for admitting the light of the star. On each side of this space is a little prism which reflects the light of a spark placed entirely to one side of the beam of light which comes from the star. Between each prism and its spark a small lens is inserted, so that an image of the spark is formed at the slit, just next to that part which admits the light of the star. In order to photograph the spark-spectrum, the observer simply turns on an electric switch for a few seconds. Mr. Wright's invention, like the automatic heating apparatus previously described, economizes the observer's time and attention; besides, it lessens the chance of deranging the spectroscope.

V. The Color Screen (for photographing with a visual telescope).—A telescope used for photography must have an objective which is corrected for the blue and violet rays of light, since to these the photographic film is most sensitive. Such a telescope is nearly useless for visual observations, because those rays to which the eye is sensitive, the yellow and the green, are not brought to a focus. On the other hand, a visual telescope (corrected for these latter rays) cannot ordinarily be used for photography. Mr. Ritchey, of the Yerkes Observatory, has however, pointed out a simple expedient by which this can be done. Immediately in front of the photographic plate is placed a sheet of plate glass, which is so colored as to be opaque to the blue and violet rays, while allowing the green and yellow to pass through with nearly undiminished intensity. The blue rays are cut out before they can reach the photographic plate, and are not allowed to blur the picture. Furthermore, Mr. Ritchey uses isochromatic plates, (which are much more sensitive to yellow light than ordinary plates), and thus the length of exposure is cut down. Nevertheless, even with isochromatic plates, considerably longer exposures are necessary than if the objective had in the first place been corrected for photography. Mr. Ritchey has obtained some beautiful large-scale photographs of the Moon and other objects by means of color-screen and the great visual refractor of the Yerkes Observatory.

Publications of the Astronomical Society of the Pacific.
Volume XIV, Number 84, 1902.

A PHOTOGRAPH OF THE NEBULA H.V 15 = N.G.C. 6960.

H. C. WILSON.

For Popular Astronomy.

The photograph from which Plate XIV was prepared was taken with the 8-inch Clark Photographic Refractor of Goodsell Observatory, on the nights of Oct. 31, Nov. 1, Nov. 7 and Nov. 8, 1901, the total exposure being $11^h\ 36^m$. The plate used was a Cramer Crown and it was developed with a strong Hydrochinon developer. The photograph has been enlarged about two and one-half diameters in the reproduction.

The bright star on the right edge of the nebula is 52 Cygni, R. A. $20^h\ 39^m\ 53^s$, Decl. $+ 30°\ 12'.7$ (1860.0). It is incorrectly called κ Cygni in Dreyer's New General Catalogue of Nebulæ. It is the only star shown in the photograph which is visible to the naked eye.

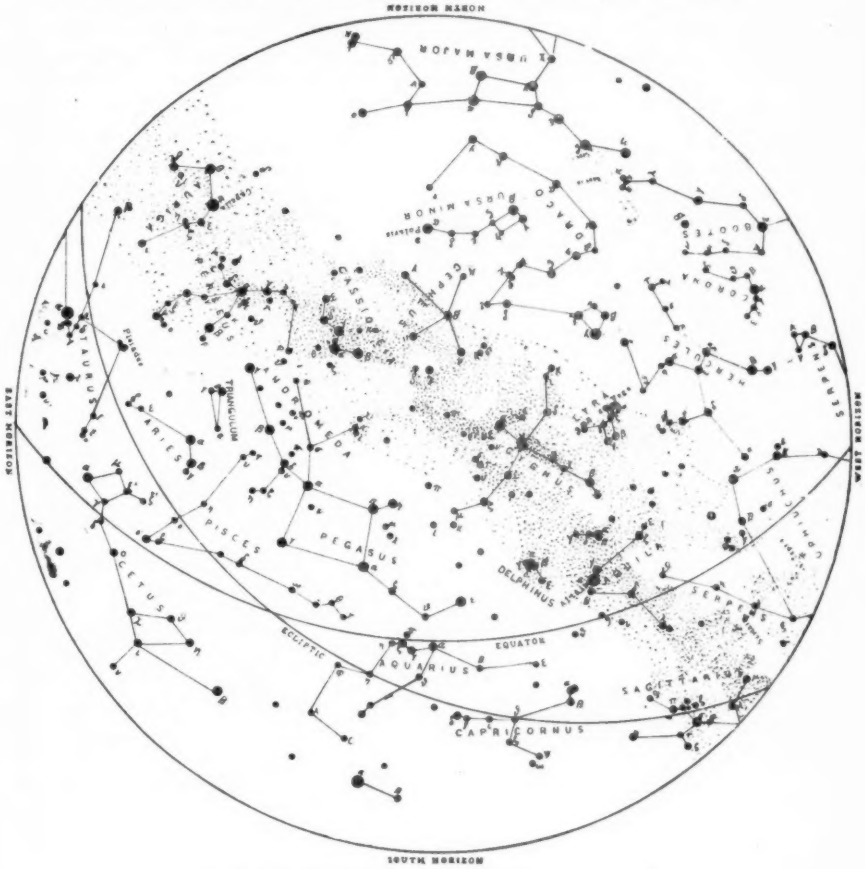
The nebula was discovered by Herschel Sept. 7, 1784, and was numbered 15 in his fifth catalogue of nebulæ. It is described by Herschel as extending over more than 1°, indeed with the highest power almost 2°. In the photograph here shown, the bright part of the nebula extends, north and south, just a little more than 1°. It is about 6′ wide toward the south end and runs nearly to a sharp point toward the north. Its structure is very curious, not only in the peculiar outline of the nebula but in the character of the little, interlacing, curved cloudlets of which it is composed. One of the little cloudlets passes directly through the image of the star 52 Cygni, but whether the nebula has any real connection with the star may be doubted.

In the left-hand, eastern portion of the photograph there are many smaller nebulous patches which may, with longer exposure, prove to be fragments of a much greater nebula, of which the one near 52 Cygni and the still brighter and larger nebula H. V 14, about 2° to the east and 1° north of 52 Cygni, are but the brightest portions. In fact photographs taken on the above-mentioned nights with the 2½ and 6-inch cameras fill this region full of nebulæ and it is possible that the nebula extends as far north as λ Cygni, but in the large Milky Way cloud which surrounds ϵ and λ Cygni it is difficult to distinguish between true nebula and the light of the dense background of faint stars. The area to the east and north of 52 Cygni which is nearly filled with true nebula is roughly circular and little over 2° in diameter.

PLANET NOTES FOR OCTOBER.

H. C. WILSON.

Mercury will be evening star during the first half of the month, but will be too near the Sun, after the first few days, to be visible to the naked eye. The planet will be at inferior conjunction Oct. 19 at 1 P. M., Central Standard time, and will become visible as morning planet during the last days of the month.



THE CONSTELLATIONS AT 9 P. M. OCTOBER 1, 1902.

Venus is getting well behind the Sun, and will be visible for only a little while before sunrise each morning. On the 23d at 3 P. M. Venus and Mercury will be in conjunction, but probably neither planet can be seen at this time on account of their proximity to the Sun.

Mars is morning star, being near the meridian at 8h A. M. The altitude of the planet at 6h A. M. is good and the more prominent markings of its surface may be seen, but the diameter of the disk is only 5″, so that the detection of the finer markings is yet almost hopeless. Mars is moving eastward, and is now entering the constellation Leo. On the 19th the planet will pass the first magnitude star Regulus, the apparent distance between the two objects being about one degree at the time of their conjunction.

Jupiter is a splendid object to the naked eye nowadays, seen near the meridian at eight o'clock in the evening. The view through the telescope is generally disappointing because of the low altitude and the consequent atmospheric tremors through which we must look at the planet. Jupiter completes his retrograde movement Oct. 3, and will for the next nine months move eastward. The westward annual movement of the heavens will soon, however, carry the planet out of view.

Saturn, being further west than Jupiter, will be carried out of sight in the glare of the Sun sooner than Jupiter but will be visible for a short time in the early evening during this month, being near the meridian at seven o'clock on the first, and at 5 o'clock on the last days of the month. Saturn will be at quadrature, 90° east from the Sun, Oct. 15.

Uranus is too far to the west to be observed except in the earliest hours of the evening.

Neptune is near the meridian at five o'clock in the morning, in the constellation Gemini. This constellation is above the horizon toward the northeast at midnight, and soon after that time the planet may be found, with the aid of a good telescope, among the faint stars in the same field of view with μ Geminorum.

The Moon.

	Phases.		Rises. (Central Standard Time at Northfield 13m less.)		Sets. Local Time	
			h	m	h	m
Oct.	1	New Moon	6	06 A. M.	5	50 P. M.
	9	First Quarter	1	24 P. M.	11	21 "
	16-17	Full Moon	5	12 "	6	53 A. M.
	23-24	Last Quarter	11	25 "	1	45 P. M.
	31	New Moon	7	03 A. M.	5	26 "

Occultations Visible at Washington.

Date. 1902.	Star's Name.	Magnitude.	IMMERSION. Washington M.T. h	m	Angle from N pt. °	EMERSION. Washington M. T. h	m	Angle from N pt. °	Duration. h	m
Oct. 9	ρ^1 Sagittarii	3.9	5	11	155	5	42	182	0	31
10	B.A.C. 6992	6.2	11	35	120	12	16	202	0	41
10	β Capricorni	3.4	11	45	126	12	21	197	0	36
11	ν Aquarii	4.6	11	58	0	12	24	316	0	26
13	B.A.C. 7951	6.7	10	41	79	11	56	227	1	15
14	12 Piscium	6.8	4	35	88	5	35	230	1	00
14	21 Piscium	6.1	16	47	111	17	27	214	0	40
16	ζ Piscium	5.4	4	13	75	5	03	249	0	50
19	δ^1 Tauri	4.0	10	08	82	11	13	252	1	05
19	δ^2 Tauri	5.7	10	45	118	11	37	216	0	52
19	δ^3 Tauri	5.0	11	44	24	12	27	311	0	43
20	119 Tauri	4.6	13	55	69	15	12	285	1	17
20	120 Tauri	5.3	14	38	84	16	00	274	1	22
21	Lalande 12148	7.0	9	22	153	9	44	203	0	22
21	21 Geminorum	6.5	13	10	107	14	21	255	1	11
21	20 Geminorum	6.3	13	11	108	14	23	253	1	12
22	68 Geminorum	5.0	14	10	139	15	05	235	0	45

Phenomena of Jupiter's Satellites.

Central Standard Time.

	h	m				h	m			
Oct.	1	6	18 P. M.	III	Oc. Re.	Oct. 15	10	09 P. M.	III	Oc. Dis.
		7	25 "	III	Ec. Dis.	16	7	12 "	II	Sh. In.
		9	19 "	IV	Oc. Dis.		7	30 "	II	Tr. Eg.
		10	58 "	III	Ec. Re.		10	08 "	II	Sh. Eg.
	2	9	49 "	I	Oc. Dis.	18	7	07 "	IV	Oc. Re.
	3	6	57 "	I	Tr. In.		8	01 "	I	Oc. Dis.
		8	08 "	I	Sh. In.	19	6	28 "	I	Sh. In.
		9	17 "	I	Tr. Eg.		7	31 "	I	Tr. Eg.
		10	29 "	I	Sh. Eg.		8	48 "	I	Sh. Eg.
	4	7	47 "	I	Ec. Re.		8	59 "	III	Sh. Eg.
	7	6	58 "	II	Oc. Dis.	20	6	06 "	I	Ec. Re.
	8	6	20 "	III	Oc. Dis.	23	7	06 "	II	Tr. In.
		10	02 "	III	Oc. Re.		9	48 "	II	Sh. In.
		11	26 "	III	Ec. Dis.		10	03 "	II	Tr. Eg.
	9	7	31 "	II	Sh. Eg.	25	6	56 "	II	Ec. Re.
	10	6	16 "	IV	Sh. In.	26	7	04 "	I	Tr. In.
		8	48 "	I	Tr. In.		7	36 "	III	Tr. Eg.
		10	04 "	I	Sh. In.		8	24 "	I	Sh. In.
		11	09 "	I	Sh. Eg.		9	17 "	III	Sh. In.
		11	11 "	IV	Sh. Eg.		9	25 "	I	Tr. Eg.
	11	9	42 "	I	Ec. Re.	27	5	26 "	IV	Sh. Eg.
	12	5	37 "	I	Tr. Eg.		9	02 "	I	Ec. Re.
		6	53 "	I	Sh. Eg.	28	5	14 "	I	Sh. Eg.
	14	9	29 "	I	Oc. Dis.					

NOTE.—In. denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

A Total Eclipse of the Moon Oct. 16, 1902.—This will be visible generally throughout North and South America and the beginning will be visible in the western part of Europe and Africa. The Moon will pass almost centrally through the Earth's shadow, the latter touching the Moon's edge first at a point 86° to the east of the north point, and leaving it at a point 118° to the west from the north point. The noticeable part of the eclipse will begin at $10^h\ 17^m$ P. M. Oct. 16 and end at $1^h\ 50^m$ A. M. Oct. 17, Central Standard time.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of conjunction in right ascension, Oct. 16, $18^h\ 10^m\ 12^s.7$.

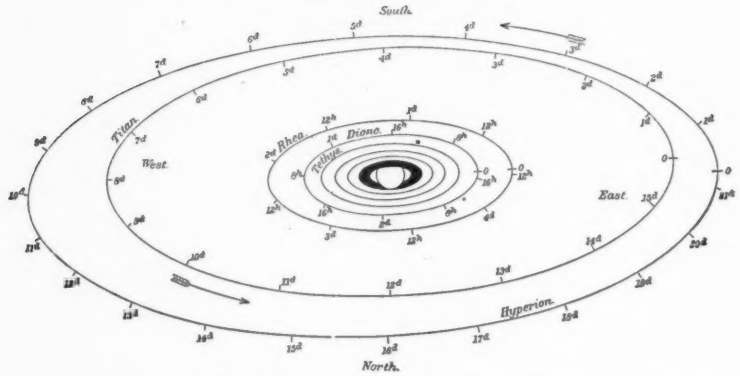
	h	m	s			s
Sun's right ascension	13	24	52.58	Hourly motion		9.33
Moon's right ascension	1	24	52.58	Hourly motion		138.31
Sun's declination	8°	55′	20″.5S	Hourly motion	0′	55″.2 S
Moon's declination	9	08	52 .7N	Hourly motion	10	26 .4N
Sun's equa. hor. parallax			8 .8	Sun's true semidiam.	16	03 .1
Moon's equa. hor. parallax		89	13 .2	Moon's " "	16	08 .3

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich M. T.			Central Standard Time.			
		h	m		h	m	
Moon enters penumbra	Oct. 16	15	17.1	Oct. 16	9	17.1	P. M.
Moon enters shadow		16	17.3		10	17.3	"
Total eclipse begins		17	19.0		11	19.0	"
Middle of eclipse		18	03.4	17	12	03.4	A. M.
Total eclipse ends		18	47.9		12	47.9	"
Moon leaves shadow		19	49.7		1	49.7	"
Moon leaves penumbra		20	50.0		2	50.0	"

Magnitude of the eclipse = 1.464 (Moon's diameter = 1.0).

The Satellites of Saturn.



APPARENT ORBITS OF THE SEVEN INNER SATELLITES OF SATURN, AT OPPOSITION IN 1902 AS SEEN IN AN INVERTING TELESCOPE.

I. MIMAS.

Period 0^d $22^h.6$

		h		
Oct.	1	5.5	P. M.	E
	2	4.1	"	E
	6	10.0	"	W
	7	8.6	"	W
	8	7.2	"	W
	9	5.8	"	W
	10	4.4	"	W
	14	10.3	"	E
	15	8.9	"	E
	16	7.5	"	E
	17	6.1	"	E
	18	4.7	"	E
	23	9.2	"	W
	24	7.8	"	W
	25	6.4	"	W
	26	5.0	"	W
	27	3.6	"	W

II. ENCELADUS.

Period 1^d $8^h.9$

		h		
Oct.	2	10.0	A. M.	E
	3	6.9	P. M.	E
	5	3.8	A. M.	E
	6	0.7	P. M.	E
	7	9.6	"	E
	9	6.5	A. M.	E
	10	3.4	P. M.	E
	12	12.3	A. M.	E
	13	9.2	"	E
	14	6.1	P. M.	E
	16	3.0	A. M.	E
	17	11.9	"	E
	18	8.7	P. M.	E
	20	5.6	A. M.	E
	21	2.5	P. M.	E
	22	11.4	A. M.	E
	24	8.3	A. M.	E
	25	5.2	P. M.	E

II. ENCELADUS.—Con.

Period 1^d $8^h.9$

		h		
Oct.	27	2.1	A. M.	E
	28	11.0	"	E
	29	7.9	P. M.	E
	31	4.8	A. M.	E

III. TETHYS.

Period 1^d $21^h.3$

		h		
Oct.	1	5.5	P. M.	E
	3	2.9	"	E
	5	0.2	"	E
	7	9.5	A. M.	E
	9	6.8	"	E
	11	4.1	"	E
	13	1.4	"	E
	14	10.8	P. M.	E
	16	8.1	"	E
	18	5.4	"	E
	20	2.7	"	E
	22	0.1	"	E
	24	9.4	A. M.	E
	26	6.7	"	E
	28	4.0	"	E
	30	1.3	"	E
	31	10.7	P. M.	E

IV. DIONE.

Period 2^d $17^h.7$

		h		
Oct.	3	5.0	A. M.	E
	5	10.7	P. M.	E
	8	4.4	"	E
	11	10.1	A. M.	E
	14	3.8	"	E
	16	9.5	P. M.	E
	19	3.2	"	E
	22	8.9	A. M.	E
	25	2.7	"	E
	27	8.4	P. M.	E
	30	2.1	"	E

V. RHEA.

Period 4^d $12^h.5$

		h		
Oct.	3	5.5	P. M.	E
	8	5.9	A. M.	E
	12	6.4	P. M.	E
	17	6.9	A. M.	E
	21	7.3	P. M.	E
	26	7.8	A. M.	E
	30	8.4	P. M.	E

VI. TITAN.

Period 15^d $23^h.3$

		h		
Oct.	2	7.6	P. M.	S
	6	6.9	"	E
	10	9.4	"	I
	14	9.6	"	W
	18	6.7	"	S
	22	6.1	"	E
	26	8.5	"	I
	30	8.7	"	W

VII. HYPERION.

Period 21^d $7^h.6$

		h		
Oct.	5	10	A. M.	S
	9	9	P. M.	E
	14	4	"	I
	20	4	"	W
	26	1	"	S
	31	4	A. M.	E

VIII. IAPETUS.

Period 79^d $22^h.1$

Sept.	28.9	S	
Oct.	18.1	E	
Nov.	6.8	I	

A Partial Eclipse of the Sun Oct. 30, 1902.—This will not be visible in America, but will be seen in Asia and the northern and eastern parts of Europe. At the maximum of the eclipse about seven-tenths of the diameter of the Sun's disk will be covered by the Moon. The eclipse begins at $11^h\ 58^m.6$ P. M. Oct. 30 and ends at $4^h\ 02^m.4$ A. M., Oct. 31, Central Standard time.

Sunspots.—Almost no sunspots have been visible during the past summer and autumn. On June 3 one small spot with many faculæ around it was seen at Northfield. July 7 four tiny black spots were observed. Aug. 15 two tiny spots, each surrounded by many faculæ were seen near the east limb of the Sun. Sept. 13 many faculæ were seen near the east limb and one tiny spot, hardly dark enough to be called a spot, was detected among the faculæ. On Sept. 18 a small group of inconspicuous spots was observed, probably in the same position as the group of Sept. 13, but near the center of the solar disk.

COMET AND ASTEROID NOTES.

New Comet *b*, 1902 (Perrine).—A new comet was discovered by C. D. Perrine of Lick Observatory on the morning of Sept. 1. Mr. Perrine describes it as "of about the 9th magnitude, with a nucleus of 10½ or 11 magnitude. The nucleus was not stellar although well defined. The coma was 4′ or 5′ in diameter, and a short brushy tail could be traced to the southwest for 8′ or 10′." Observations were secured on three successive mornings by Mr. Perrine giving the following positions of the comet:

Mt. Hamilton M. T.				R. A.			Decl.			Observer.
	h	m	s	h	m	s	°	′	″	
Aug. 31	16	08	18	3	17	49.36	+34	38	47.0	Perrine
Sept. 1	14	31	48	3	17	02.98	+35	00	33.9	"
2	13	13	28	3	16	09.65	+35	23	34.7	"

These observations were communnicated by telegraph to the various observatories and on Sept. 3 Mr. Perrine issued the following elements computed by himself:

$$\left.\begin{aligned} T &= 1902\ \text{Nov. } 23.472\ \text{Greenwich M. T.} \\ \omega &= 153^\circ\ 25'\ 46'' \\ \Omega &= 49\ \ 56\ \ 10 \\ i &= 156\ \ 54\ \ 22 \end{aligned}\right\} 1902.0$$
$$\log q = 9.60424$$

The equations for the coördinates referred to the equator of 1902.0, from these elements as given in *Bulletin No. 22* of Lick Observatory, are:

$$x = r\,[9.97949]\ \sin(195^\circ\ 51'\ 56'' + v)$$
$$y = r\,[9.99603]\ \sin(228\ \ 18\ \ 48 + v)$$
$$z = r\,[9.51712]\ \sin(221\ \ 14\ \ 34 + v)$$

The following ephemeris shows that the comet will probably be much brighter in October than at the time of discovery; and that its nearest approach to the Earth will occur early in the month. On Oct. 5 it will be nearly overhead, in our northern latitudes at nine o'clock in the evening:

EPHEMERIS FOR GREENWICH MIDNIGHT.

	R. A.			Decl.		log Δ	Brightness.
	h	m	s	°	′		
Sept. 6.5	3	11	40	+37	01	0.043	1.50
10.5	3	04	16	+39	12	9.988	2.10
14.5	2	52	44	+41	53	9.927	3.02
18.5	2	34	28	+45	14	9.858	4.52
Oct. 5.5	20	45	49	+50	28	9.566	27.1
22.5	17	43	15	+ 3	53	9.812	16.1
Nov. 8.5	16	57	23	−11	00	0.040	13.9
23.5	16	13	08	−18	13	0.139	17.2

The comet was observed at Northfield on the night of Sept. 24 and was found to be just visible to the naked eye. With field glass it could be very easily picked up, and appeared nearly as bright as, but somewhat smaller than, the Andromeda Nebula. With the 16-inch telescope the nucleus was very definite but not quite stellar; and the coma filled the whole field of view, 10′ in diameter. In the 5-inch finder a faint tail could be seen, extending about 20′ toward the southeast. The observed position was:

Northfield M. T.	R. A. App.	Decl. App.	Observer.
$10^h\ 21^m\ 16^s$	$1^h\ 40^m\ 13^s.11$	$+51°\ 51'\ 36''.4$	Wilson

Elements and Ephemeris of Comet *b* 1902 (Perrine).—The following are given in a supplement to *A. N.* 3812, and were computed by Elis Strömgren, of Kiel, Germany, from observations at Lick Sept. 1.05, Urania Sept. 2.58 and Copenhagen Sept. 4.61:

ELEMENTS.

$T = 1902$ Nov. 23.215 Berlin.
$\omega = 153°\ 53'.2$
$\Omega = 50\ 10.6$ } 1902.0
$i = 157\ 08.2$
$\log q = 9.60094$

EPHEMERIS FOR BERLIN MIDNIGHT.

	R. A.	Decl.	log r	log Δ	Brightness.
	h m s	° ′			
Sept. 6	3 11 48	+37 00.3	0.2290	0.0420	1.50
10	3 04 26	+39 10.4	0.2117	9.9870	2.09
14	2 52 59	+41 51.4	0.1935	9.9255	3.02
18	2 34 47	+45 13.2	0.1743	9.8566	4.54
22	2 04 19	+49 23.3	0.1538	9.7801	7.09
26	1 10 01	+54 03.8	0.1321	9.6982	11.42

New Comet *c*? 1902 (Grigg).—A telegram received Sept. 17 from Professor Kreutz at Kiel Observatory, via Harvard College Observatory, announced the discovery of a comet by Grigg at New Zealand, July 22. The predicted place for Sept. 17·000 was in R. A. $15^h\ 37^m\ 16^s$ and Decl. $-7°\ 58'$. Daily motion in R. A $+2^h\ 32^s$ and Decl. $-0°\ 07'$. The predicted place was given as only a rough approximation, and it was stated that the brightness of the comet had rapidly decreased.

Elements of Planet 1902 HS = (359) [1893M].—In *A. N.* 3806 Dr. Berberich gives the following elements of Planet 1902 HS:

Epoch 1902 May 2.5 Berlin M. T.

$M = 203°\ 00'\ 32''.1$
$\omega = 336\ 37\ 31\ .1$
$\Omega = 6\ 34\ 38\ .0$ } 1902.0
$i = 6\ 48\ 28\ .0$

$\phi = 8°\ 58'\ 30''.9$
$\mu = 787''.647$
$\log a = 0.435783$

With a change of $+40'$ in M these elements will represent the observations of (359) [1893M] on March 11 and 17, 1893 so well that the identity of the two planets is beyond doubt.

In *A. N.* 3809 the planet is given the name Georgia.

Search Ephemeris for Comet Temple-Swift.—In *A. N.* 3811 Mr. J. Bossert gives the following ephemeris of the periodic comet discovered by

Temple in 1869 and by Swift in 1880. Its position is comparatively favorable this year and the comet ought soon to be picked up:

EPHEMERIS.

1902.	α	δ	log r	log Δ
	h m s	° ′		
Sept. 1	18 57 54	−20 10.6	0.3064	0.1044
6	55 52	20 3.7	2978	1083
11	55 17	19 55.4	2890	1129
16	55 46	19 46.2	2800	1180
21	57 20	19 36.1	2708	1233
26	18 59 53	19 24.9	2614	1285
Oct. 1	19 3 28	19 12.2	2518	1335
6	8 1	18 58.1	2421	1385
11	13 30	18 42.3	2321	1432
16	19 51	18 23.8	2220	1471
21	27 4	18 3.0	2117	1507
26	35 8	17 38.8	2013	1535
31	43 54	17 12.0	1909	1563
Nov. 5	19 53 28	−16 41.3	0.1803	0.1582

New Asteroids.—The following have been added to the list of newly discovered planets since our last note:

				Local M. T.	R. A.	Decl.	Mag.
				h m	h m	° ′	
1902	J M	Carnera	Heidelberg	Sept, 2 14 15.3	22 44.7	−5 29	—
	J N	Wolf	"	4 12 45.8	0 39.5	−0 52	12

VARIABLE STARS.

Variable Star Observations.—In *A. N.* 3809 Mr. K. Bohlin gives a valuable series of variable star observations made at the Upsala Observatory in the years 1895-6. Following these observations, he gives a collection of the results obtained by other observers for the same stars during the period 1890 to 1900, in comparison with his own results.

New Algol-Type Variable 13.1902 Lyræ.—In *A. N.* 3811 Mr. A. Stanley Williams announces the discovery of a new Algol-type variable with a period of about 3.6 days. The star is a faint one, normally of about the 11th magnitude and sinks at minimum nearly to the limit of visibility with a 6.5-inch reflector, or about 12.8 magnitude. Its position for 1855.0 is

$$\text{R. A.} = 19^h\ 10^m\ 48^s.7, \qquad \text{Decl.} = +32°\ 10'.1$$

"It is easily found, as it is the most following, and normally the brightest, of three stars forming a small triangle south of the 9.1 mag. star BD + 32°3377. The magnitude of the southernmost star (*d*) of the triangle according to my observations is 11.78; and that of a star (*b*) nearly midway between BD + 32°3376 (9.2) and BD + 32°3377 (9.1), but a little following a straight line joining the two, is 10.62 . . . ."

"The star remains at normal brightness for about $3^d\ 6^h\ 22^m$, the increase and decrease each requiring about four hours. There is apparently no stationary interval at minimum."

Mr. Williams gives the following elements of the star's variation:

$$\text{Min.} = 1902 \text{ July } 29,\ 11^h\ 52^m.7 \text{ Gr. M. T.} + 3^d\ 14^h\ 22^m\ 23^s.5\ E$$
$$= \text{J. D. } 2415960.4948 + 3^d.598883\ E.$$

Minima may be expected Oct. 4, 19^h; 6, 9^h; 9, 23^h; 13, 13^h; 17, 4^h; 20, 18^h; 24, 9^h; 27, 23^h; 31, 13^h.

Minima of Variable Stars of the Algol Type.

[Greenwich Mean Time beginning with midnight. The hours greater than 12 are those of the afternoon. To obtain Eastern Standard time subtract 5 hours; for Central Standard subtract 6 hours, etc.]

U Cephei.

	d	h
Oct.	1	23
	4	11
	6	23
	9	11
	11	23
	14	10
	16	22
	19	10
	21	22
	24	10
	26	22
	29	9
	31	21

Algol.

	d	h
Oct.	2	12
	5	9
	8	6
	11	3
	13	23
	16	20
	19	17
	22	14
	25	11
	28	7
	31	4

λ Tauri.

	d	h
Oct.	1	13
	5	12
	9	11
	13	10
	17	8
	21	7
	25	6
	29	5

R Canis Majoris

	d	h
Oct.	1	6
	2	9
	3	13
	4	16
	5	19
	6	22
	8	2
	9	5
	10	8
	11	11
	12	15
	13	18
	14	21
	16	0
	17	4

R Can. Maj. Con

	d	h
Oct.	18	7
	19	10
	20	13
	21	17
	22	20
	23	23
	25	3
	26	6
	27	9
	28	12
	29	16
	30	19
	31	22

S Cancri.

	d	h
Oct.	1	17
	11	5
	20	16
	30	4

S Antliæ.

Period $7^h\ 46^m.8$

	d	h
Oct.	1	15
	2	14
	3	14
	4	13
	5	12
	6	12
	7	11
	8	10
	9	10
	11	9
	12	8
	13	8
	14	7
	15	6
	16	6
	17	5
	18	4
	19	4
	20	3
	21	2
	22	2
	23	1
	24	0
	25	0
	25	23
	26	22
	27	22
	28	21
	29	20
	30	20
	31	19

U Coronæ.

	d	h
Oct.	3	19
	7	6
	10	17
	14	4
	17	15
	21	2
	24	13
	27	23
	31	10

U Ophiuchi.

	d	h
Oct.	1	13
	2	9
	3	5
	4	1
	4	21
	5	18
	6	14
	7	10
	8	6
	9	2
	9	22
	10	18
	11	14
	12	11
	13	7
	14	3
	14	23
	15	19
	16	15
	17	11
	18	7
	19	4
	20	0
	20	20
	21	16
	22	12
	23	8
	24	4
	25	1
	25	21
	26	17
	27	13
	28	9
	29	5
	30	1
	30	21
	31	18

RX Herculis.

	d	h
Oct.	1	13
	2	11
	3	8
	4	5
	5	3
	6	0
	6	21
	7	19
	8	17
	9	14
	10	11
	11	9
	12	6
	13	3
	14	0
	14	22
	15	19
	16	16
	17	14
	18	11
	19	8
	20	6
	21	3
	22	0
	22	22
	23	19
	24	16
	25	14
	26	11
	27	8
	28	6
	29	3
	30	0
	30	22
	31	19

Z Herculis.

	d	h
Oct.	2	12
	4	11
	6	12
	8	11
	10	12
	12	11
	14	12
	16	11
	18	12
	20	11
	22	11
	24	10
	26	11
	28	10
	30	11

SY (V^3) Cygni.

	d	h
Oct.	3	12
	9	12
	15	12
	21	13
	27	13

SW (U^3) Cygni.

	d	h
Oct.	3	19
	8	9
	12	23
	17	12
	22	2
	26	16
	31	6

W Delphini.

	d	h
Oct.	2	23
	7	18
	12	13
	17	9
	22	4
	26	23
	31	18

Y Cygni.

	d	h
Oct.	1	23
	3	8
	4	23
	6	7
	7	23
	9	7
	10	23
	12	7
	13	23
	15	7
	16	23
	18	7
	19	23
	21	7
	22	23
	24	7
	25	23
	27	7
	28	23
	30	7
	31	22

Variable Stars of Short Period not of the Algol Type.

	Minimum.		Maximum.			Minimum.		Maximum.	
		h		h			h		h
U Sagittarii	Oct. 2	8	Oct. 5	7	Y Sagittæ	Oct. 16	7	Oct. 18	2
δ Cephei	2	18	4	9	T Vulpeculæ	17	11	18	20
U Aquilæ	3	12	5	16	U Aquilæ	17	13	19	17
T Vulpeculæ	4	4	5	13	X Sagittarii	18	6	21	3
X Sagittarii	4	6	7	3	δ Cephei	18	20	20	11
Y Sagittarii	4	18	6	13	β Lyræ	19	12	22	21
ζ Geminorum	4	19	9	19	W Geminorum	20	22	23	13
T Monocerotis	5	2	13	0	T Vulpeculæ	21	21	23	6
W Geminorum	5	10	8	1	Y Sagittarii	22	2	23	21
β Lyræ	6	14	9	23	η Aquilæ	22	11	24	17
S Sagittæ	7	19	11	5	U Sagittarii	22	14	25	13
η Aquilæ	8	2	10	8	W Sagittarii	23	9	26	9
δ Cephei	8	3	9	18	δ Cephei	24	5	25	19
W Sagittarii	8	4	11	4	U Aquilæ	24	14	26	18
T Vulpeculæ	8	14	9	23	S Sagittæ	24	14	28	0
U Sagittarii	9	2	12	1	ζ Geminorum	25	2	30	2
Y Ophiuchi	10	8	16	13	X Sagittarii	25	7	28	4
U Aquilæ	10	12	12	16	β Lyræ	25	23	29	1
Y Sagittarii	10	13	12	8	T Vulpeculae	26	8	27	17
W Virginis	10	21	19	0	X Cygni	27	15	3	10
X Sagittarii	11	6	14	3	Y Ophiuchi	27	10	2	15
X Cygni	11	6	18	1	Y Sagittarii	27	20	29	15
T Vulpeculæ	13	1	14	10	W Virginis	28	3	5	7
β Lyræ	13	1	16	3	W Geminorum	28	15	31	6
W Geminorum	13	4	15	19	U Sagittarii	29	8	1	7
δ Cephei	13	12	15	3	δ Cephei	29	14	31	5
ζ Geminorum	14	22	19	22	η Aquilae	29	15	31	21
η Aquilæ	15	7	17	13	T Vulpeculæ	30	18	1	3
W Sagittarii	15	19	18	19	W Sagittarii	30	23	2	23
U Sagittarii	15	20	18	19	U Aquilæ	31	14	2	18
S Sagittarii	16	5	19	15					

Maxima and Minima of Long Period Variables.

[Computed from Chandler's "Third Catalogue" by Misses Ida I. Watson and Helen M. Swartz of Vassar College Observatory.]

Maxima.			Maxima.		
Date Oct.	No.	Star.	Date Nov.	No.	Star.
2	1113	U Arietis	4	8230	S Aquarii
3	4596	U Virginis	5	7085	RT Cygni
5	3425	X Hydrae	10	3170	S Hydrae
7:	5928	T Ophiuchi	11	1981	S Camelopardalis
11:	1805	V Orionis	11	5494	S Librae
11	2625	V Geminorum	13	5190	R Camelopardalis
12	6449	T Draconis	13	7560	R Vulpeculae
19	2478	R Lyncis	14	2742	S Geminorum
19	7458	V Delphini	16	6207	Z Ophiuchi
20	7444	T Delphini	18	1944	S Orionis
21	7577	X Capricorni	18	6903	T Sagittarii
23:	7456	RR Cygni	20	7571	V Capricorni
26	243	U Cassiopeae	21	5194	V Bootis
26	5157	S Bootis	22:	6900	W Aquilae
26	5955	R Draconis	24	2691	T Canis minoris.
26	7242	S Aquilae	26	7450	V Aquarii
27	8622	W Ceti	27	5704	RR Librae
29	114	S Ceti	27	7754	W Cygni
29	5511	RS Librae	29	3493	R Leonis
29	8153	R Lacertae			
31	845	R Ceti			

Maxima and Minima of Long Period Variables.—Continued.

Minima. Date. Oct.	No.	Star.	Minima. Date. Nov.	No.	Star.
2	1717	V Tauri	2	5237	R Bootis
6	4521	R Virginis	6	7468	T Aquarii
6	7261	R Delphini	7	1222	R Persei
13	5795	W Scorpii	14	906	R Trianguli
15	8373	S Pegasi	18	1577	R Tauri
21	5430	T Librae	23	976	T Arietis
22	5504	S Coronae	25	7448	W Aquarii
23	4557	S Ursae Majoris	26	2258	V Aurigae
24	7192	Z Cygni	28	5887	V Ophiuchi

Maxima of U Pegasi.

Period $4^h\ 29^m.8$. The minimum occurs $2^h\ 15^m$ after the maximum.

	d	h		d	h		d	h		d	h
Oct.	1	5	Oct.	9	2	Oct.	17	3	Oct.	25	4
	2	4		10	5		18	2		26	3
	3	2		11	3		19	5		27	1
	4	5		12	2		20	3		28	4
	5	3		13	5		21	2		29	3
	6	2		14	3		22	4		30	1
	7	5		15	2		23	3		31	4
	8	3		16	5		24	1			

Naming of Recently Discovered Variable Stars.—In *A. N.* 3808 the committee for the preparation of a catalogue of Variable Stars, Messrs. Dunér, Hartwig, Müller and Oudemans, publishes the following list of stars discovered in the past two years, whose variability has been established, and which are therefore entitled to permanent designation.

No. after Chandler.	Prov. Des. A. N.	Name.	Position 1900.0. R. A.			Decl.	
			h	m	s	°	′
885	——	X Eridani	2	27	26	− 41	54.1
1232	——	T Fornacis	3	25	24	− 28	44.8
2096	8.1902	V Camelopardalis	5	49	24	+ 74	29.9
2709	27.1900	S Volnatis	7	31	29	− 73	9.9
3394	97.1901	Y Velorum	9	25	40	− 51	44.6
3536	28.1900	Z Velorum	9	49	25	− 53	42.5
3707	91.1900	RR Velorum	10	17	48	− 41	51.3
4055	98.1901	RY Carinae	11	15	49	− 61	19
4953	——	RX Centauri	13	45	33	− 36	26.8
4957	29.1990	T Apodis	13	46	6	− 77	18.5
5928	77.1901	SS Herculis	16	28	1	+ 7	3.0
6513	6.1902	W Draconis	18	5	27	+ 65	56.5
6521	7.1902	X Draconis	18	6	47	+ 66	8.3
6827	5.1902	RT Lyrae	18	57	46	+ 37	22.4
6895	11.1902	RU Lyrae	19	9	6	+ 41	8.1
6927	98.1901	U Sagittae	19	14	26	+ 19	25.7
7318	78.1901	UW Cygni	20	19	36	+ 42	54.9
7360	99.1901	RU Capricorni	20	26	44	− 22	1.7
7505	96.1901	UX Cygni	20	50	55	+ 30	2.0
7514	1.1902	UY Cygni	20	52	16	+ 30	2.8
7800	95.1901	RR Pegasi	21	39	59	+ 24	32.9
7891	10.1902	UZ Cygni	21	55	14	+ 43	51.9
7964	12.1902	RS Pegasi	22	7	24	+ 14	3.6
8182	2.1902	U Lacertae	22	43	39	+ 54	38.0

No. after Chandler.	Precession 1900.		Chart Place 1855.						Brightness.	
	R. A.	Decl.	R. A.			Decl.			Max.	Min.
	s	′	h	m	s	°	′			
885	+ 2.35	+ 0.27	2	26	27	−42	0.8		9.10	< 11
1232	+ 2.50	+ 0.21	3	24	22	−28	49.6		8.9	10
2096	+ 7.89	+ 0.02	5	43	29	+74	29.0		9	14
2709	+ 1.00	− 0.13	7	31	54	−73	6.6		9	< 12
3394	+ 2.02	− 0.26	9	24	49	−51	38.0		8.9	< 12
3536	+ 2.09	− 0.28	9	48	33	−53	35.5		9	< 13
3707	+ 2.56	− 0.30	10	16	44	−41	43.6		10	11
4055	+ 2.60	− 0.33	11	14	44	−61	10		10	< 12
4953	+ 3.51	− 0.30	13	44	5	−36	19.3		9	< 12
4957	+ 5.72	− 0.30	13	43	44	−77	11.0		8.9	< 12
5928	+ 2.92	− 0.13	16	25	50	+ 7	8.9		9	< 12
6513	+ 0.08	+ 0.01	18	5	23	+65	56.2		9	14
6521	+ 0.05	+ 0.01	18	6	45	+66	7.9		9.10	14
6827	+ 2.08	+ 0.08	18	56	12	+37	18.7		10.11	< 12
6895	+ 1.96	+ 0.10	19	7	37	+41	3.7		11	13
6927	+ 2.63	+ 0.11	19	12	27	+19	20.8		6.7	9
7318	+ 2.05	+ 0.19	20	18	4	+42	46.4		10.11	13
7360	+ 3.51	+ 0.20	20	24	6	−22	10.7		9	< 12
7505	+ 2.51	+ 0.23	20	49	2	+29	51.8		9.10	< 12
7514	+ 2.51	+ 0.23	20	50	23	+29	52.6		9.10	10.11
7800	+ 2.72	+ 0.27	21	37	56	+24	20.6		9	< 12
7891	+ 2.41	+ 0.29	21	53	26	+43	39.1		9	11.12
7964	+ 2.91	+ 0.30	22	5	13	+13	50.4		8.9	< 10
8182	+ 2.46	+ 0.32	22	41	49	+54	23.8		8	—

Approximate Magnitudes of Variable Stars on Sept. 17, 1902.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

	h	m	°	′			h	m	°	′		
T Androm.	0	17.2	+ 26	26	8	*d*	R Comae	11	59.1	+ 19	20	*s*
T Cassiop.	0	17.8	+ 55	14	9	*d*	T Virginis	12	9.5	− 5	29	*s*
R Androm.	0	18.8	+ 38	1	13	*i*	R Corvi	12	14.4	− 18	42	*s*
S Ceti	0	19.0	− 9	53	10	*d*	Y Virginis	12	28.7	− 3	52	*s*
W Cassiop.	0	49.0	+ 58	1	10		T Ursae Maj.	12	31.8	+ 60	2	12 *d*
S "	1	12.3	+ 72	5	14		R Virginis	12	33.4	+ 7	32	*s*
R Piscium	1	25.5	+ 2	22	8	*i*	S Urs. Maj.	12	39.6	+ 61	38	8 *d*
R Trianguli	1	31.0	+ 33	50	9	*d*	U Virginis	12	46.0	+ 6	6	*s*
U Persei	1	52.9	+ 54	20	10	*i*	V "	13	22.6	− 2	39	*s*
R Arietis	2	10.4	+ 24	36	13		R Hydrae	13	24.2	− 22	46	*s*
o Ceti	2	14.3	− 3	26	7	*d*	S Virginis	13	27.8	− 6	41	*s*
S Persei	2	15.7	+ 58	8	11		R Can. Ven.	13	44.6	+ 40	2	8 *i*
R Ceti	2	20.9	− 0	38	12	*d*	S Bootis	14	19.5	+ 54	16	12 *d*
U "	2	28.9	− 13	35		*u*	R Camelop.	14	25.1	+ 84	17	13 *d*
R Persei	3	23.7	+ 35	20	9		R Bootis	14	32.8	+ 27	10	11 *d*
R Tauri	4	22.8	+ 9	56		*f*	S Librae	15	15.6	− 20	2	*s*
S "	4	23.7	+ 9	44		*f*	S Serpentis	15	17.0	+ 14	40	9 *d*
R Aurigae	5	9.2	+ 53	28	10	*i*	S Coronae	15	17.3	+ 31	44	12 *d*
U Orionis	5	49.9	+ 20	10	9	*d*	S Urs. Min	15	33.4	+ 78	58	11 *d*
R Lyncis	6	53.0	+ 55	28	8	*i*	R Coronae	15	44.4	+ 28	28	6
R Geminorum	7	1.3	+ 22	52	8	*d*	V "	15	45.9	+ 39	52	11 *d*
S Canis Min.	7	27.3	+ 8	32	12	*d*	R Serpentis	15	46.1	+ 15	26	7 *d*
R Cancri	8	11.0	+ 12	2	8	*i*	R Herculis	16	11.7	+ 18	38	14
V "	8	16.0	+ 17	36	7	*i*	R Scorpii	16	11.7	− 22	42	13 *d*
S Hydrae	8	48.4	+ 3	27		*u*	S "	16	11.7	− 22	39	*f*
T "	8	50.8	− 8	46		*u*	U Herculis	16	21.4	+ 19	7	12 *d*
R Leonis Min.	9	39.6	+ 34	58	7	*d*	R Urs. Min.	16	31.3	+ 72	28	9 *d*
R Leonis	9	42.2	+ 11	54	9	*i*	W Herculis	16	31.7	+ 37	32	11 *d*
R Ursae Maj.	10	37.6	+ 69	18	12	*i*	R Draconis	16	32.4	+ 66	58	9 *i*

Approximate Magnitudes of Variable Stars.—Continued.

	h	m	°	′				h	m	°	′		
S Herculis	16	47.4	+ 15	7	12	*d*	U Cygni	20	16.5	+ 47	35	10	*i*
R Ophiuchi	17	2.0	− 15	38	14		V "	20	38.1	+ 47	47	14	
T Herculis	18	5.3	+ 31	0	11	*d*	T Aquarii	20	44.7	− 5	31	12	*d*
R Scuti	18	42.2	− 5	49	7	*d*	R Vulpeculae	20	59.9	+ 23	26	12	*i*
R Aquilae	19	1.6	+ 8	5	8	*d*	T Cephei	21	8.2	+ 68	5	10	
R Sagittarii	19	10.8	− 19	29	8	*d*	S "	21	36.5	+ 78	10	9	*d*
S "	19	13.6	− 19	12	11	*i*	S Lacertae	22	24.6	+ 39	48	11	
R Cygni	19	34.1	+ 49	58	7	*i*	R "	22	38.8	+ 41	51		*f*
RT "	19	40.8	+ 48	32		*u*	S Aquarii	22	51.8	− 20	53	12	*i*
X "	19	46.7	+ 32	40	4	*i*	R Pegasi	23	1.6	+ 10	0	8	*d*
S "	20	3.4	+ 57	42	11	*i*	S "	23	15.5	+ 8	22	13	
RS "	20	9.8	+ 38	28	8		R Aquarii	23	38.6	− 15	50	11	*i*
R Delphini	20	10.1	+ 8	47	12	*i*	R Cassiop.	23	53.3	+ 50	50	10	*i*

NOTE:—*f*, denotes that the variable is probably fainter than the magnitude 13; *i*, that its light is increasing; *d*, that its light is decreasing; *s*, that it is near the Sun; *u*, that its magnitdde is unknown.

Sept. 24, 1902.

New Variable Stars.—In *A. N.* 3807 Dr. Kreutz assigns the numbers 97, 98 and 99, 1901, to the following variable stars discovered by Mr. R. T. A. Innes in the course of the revision of the *Cape Photographic Durchmusterung*:

Designation.	Catalogue.	R. A. 1875. h m s	Decl. 1875. ° ′	Range.
97.1901 Velorum	C. P. D. − 51°.2275	9 24 50	− 51 38.1	8.6 to invis.
98.1901 Carinæ	Anonymous	11 14 14	− 61 10.0	9.8 " "
99.1901 Capricorni	Cord. DM. − 22°.14789	20 25 16	− 22 06.7	9.4 " "

The period of 97.1901 Velorum is still unknown, it probably exceeds 200 days. The character of 98.1901 Carinae is not completely known, it may be a nova. The period of 99.1901 Capricorni is about 353 days.

Comet *b*, 1902 (Perrine).—The following important matter pertaining to the comet came too late to be put in its proper place:

The following parabolic elements of Comet *b* 1902 are based upon the observation at time of discovery and upon two secured by me with the 12-inch equatorial on September 6 and September 12:

ELEMENTS.

$$T = 1902, \text{Nov. } 23.68125 \text{ G. M. T.}$$
$$\omega = 153^\circ\ 15'\ 18''.1$$
$$\Omega = 49\ 35\ 41\ .7$$
$$i = 156\ 34\ 19\ ,5$$
$$\log q = 9.602230$$

Residuals* (O − C).

$$\Delta\lambda' \cos\beta' = -4''.5 \qquad \Delta\beta' = +6''.2.$$

CONSTANTS FOR THE EQUATOR OF 1902.0.

$$x = r\,[9.979123] \sin(196^\circ\ 6'\ 25''.5) + v)$$
$$y = r\,[9.996371] \sin(288\ 28\ 14\ .3) + v)$$
$$z = r\,[9.517190] \sin(220\ 20\ 57\ .6) + v)$$

* These residuals could be materially improved by another approximation, but the comet's elements are so determinate that it seemed unnecessary to take time for this.

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1902.	True α. h m s	True δ. ° ′	log Δ.	Br.
Sept. 22.5	2 4 53	+49 18.5	9.7866	7.01
24.5	1 42 16	51 36.7		
26.5	1 11 50	53 55.2	9.7061	11.22
28.5	0 30 59	55 55.0		
30.5	23 37 58	57 0.5	9.6289	17.80
Oct. 2.5	22 35 4	56 20.6		
4.5	21 30 28	53 22.8	9.5761	25.45
6.5	20 32 54	48 8.0		
8.5	19 48 35	41 21.4	9.5731	29.18
10.5	19 14 38	34 10.3		
12.5	18 49 9	27 19.2	9.6204	26.81
14.5	18 29 32	21 15.5		
16.5	18 14 36	15 55.2	9.6926	22.21
18.5	18 2 30	11 26.8		
20.5	17 52 38	7 39.2	9.7684	18.34
22.5	17 44 20	4 26.3		
24.5	17 37 12	+ 1 41.8	9.8389	15.77
26.5	17 30 55	− 0 40.5		
28.5	17 25 15	2 43.8	9.9019	14.27
30.5	18 20 1	4 33.0		
Nov. 1.5	17 15 5	6 9.8	9.9573	13.62
3.5	17 10 19	7 37.3		
5.5	17 5 36	8 56.8	0.0056	13.71
7.5	17 0 46	10 10.1		
9.5	16 55 51	11 18.3	0.0473	14.45
11.5	16 50 51	12 22.7		
13.5	16 45 37	−13 23.8	0.0824	15.74

The comet's brightness has increased considerably since discovery and the nucleus has become more sharply defined, otherwise the general appearance remains as described at discovery.

R. G. AITKEN.

Sept. 1902.

GENERAL NOTES.

Important Notice.—This publication is now nearing the end of its tenth volume. Only two issues more for the two remaining months of 1902 and the tenth volume will be complete. These volumes contain about 550 pages each and in volumes I and II there is a series of 12 colored star maps that could not be reproduced for hundreds of dollars.

There remain now, only thirty-five full sets of this magazine, and for sixty days, if not previously sold, these full sets will be offered at the regular price of $2.50 per volume. The volumes are in perfect order, in pamphlet form, and will be sent to those ordering in the United States, Mexico or Canada for the price named above. Foreign subscribers should order through Messrs. Wm. Wesley & Son, 28 Essex St., Strand, London, England.

This notice has been sent to about two hundred public libraries in the United States not regular subscribers. It is believed that this offer will not last sixty days, for the opportunity of obtaining a full set of POPULAR ASTRONOMY now is a rare one. Orders should be made promptly.

There are about one hundred public libraries on our regular subscription list. If the librarians of each library will notice if all volumes are complete or not, necessary numbers may now be supplied if wanted. Later this may be impossible.

Astronomy and Astro-Physics.—The series of large volumes known as *Astronomy and Astro-Physics* consists of three in number each containing about 950 pages, fully illustrated, and covering the years of 1892, 1893 and 1894. The pamphlets making the three volumes are in perfect condition, but there are only *four* complete sets remaining. The regular price of these volumes in pamphlet form is $5.00 each and carrying charges on the same will be prepaid to any place in the United States, Mexico or Canada. Some separate volumes and numbers of this publication can be furnished if desired at proportionate rates.

Publications 2 and 3 of Goodsell Observatory have been distributed to astronomers and observatories at home and abroad. The subject matter of these publications consists of three longitude determinations. It is possible that some correspondents with whom this Observatory exchanges have not received copies of these publications. We will supply such deficiencies.

Is It Pelee Volcanic Dust?—At Alta, Iowa on September 14 the Sun was of a steel-gray to light blue color all day becoming lilac and light purple in the late afternoon. I made my usual sunspot observation about 9:00 A. M., when the sky was clear, but shortly afterwards a haze covered the sky through which the sunlight appeared of a peculiar bluish tinge. I was unable to make observations until after church services when the haze was more dense and color of sunlight, deeper blue; one could easily look at it with a very light shade of smoked glass, and at 4 P. M. without any protection to the eyes; and at this hour I could use my 4-inch glass without any special eyepiece and could observe the granulation and faculæ nicely. With the spectroscope I noticed some absorption of the red, but the G group in the violet were very conspicuous and even the H and K lines were prominent. While to the naked eye the sky appeared overcast I could easily observe the chromosphere and small prominence in the H*a* line. No aqueous vapor lines were present until about 5:00 P. M. when they were slightly visible near the D line, but the Sun was entering dense haze at this time and was deep blue to purple color. At 5:35 P. M. it became invisible. From this time on peculiar stratified clouds or haze came up from W. to NW., but at dusk brighter stars were visible and when the Moon rose about an hour it also had an ashen gray color. I am of the opinion that a cloud of volcanic dust passed over this portion of the country—I hardly think that forest fires were the cause I should be glad to hear from you with reference to the phenomenon.

DAVID E. HADDEN.

ALTA, Iowa, Sept. 15, 1902.

Under date of Sept. 19 Mr. Hadden further says: "I wrote to J. R. Sage, of our State Weather Service about the peculiar tint of the sky, and he suggests that the forest fires of the west may have been the cause but I can not agree with him. I notice that Chicago experienced pink and lavender tinted sunshine about noon on Monday, Sept. 15. I shall be glad to learn more about this phenomenon."

Mr. J. R. Sage's view is as follows:—"I noticed the blue tints of the sky on the day referred to and the hazy shades later. Previously I called attention to a peculiar glow at sunset, which reminded me of the beginning of the phenomenal exhibition in the fall of 1883. But it has not been repeated as yet.

I am inclined to the opinion that the forest fires in the northwest caused the peculiar color of the sky. It is certain that the upper currents come steadily from the westward. At great heights the finer particles of smoke produce effects

similar to the dust of volcanoes; at least, that is my present view of the question. The eruptions of Mount Pelee were quite unlike the explosion at Krakatoa and as yet we have no reports indicating that volcanic dust has been carried to great distances this year. The dust must have come from the west, whether or not it was volcanic."

Jupiter's Vth Satallite.—Under date of Sept. 9, E. E. Barnard of Yerkes Observatory, Williams Bay, Wis., writes that that day is the tenth anniversary of the discovery of the 5th satellite of Jupiter. He has obtained several good elongations of the satellite this year, the first time he has been able to see it since the spring of 1899. This tiny object is so faint that favorable opportunity and a large telescope are necessary to see it at all.

Dark Transit of Jupiter's Satellite III.—On the evening of Sept. 13th at 7^h, 90th M. T., I observed Satellite III as a jet black spot, clear cut and circular and apparently much smaller than normal. As it passed along below and very near the northern equatorial belt I detected no change until near the western edge of the planet it gradually grew less distinct, becoming invisible in my 5-inch Clark telescope three minutes before egress.

After egress it appeared as a reddish brown ball. I estimated its brilliancy to be approximately one-third that of normal or one-half that of No. II.

The only striking difference between this and four previous dark transits of this satellite which I have witnessed was the peculiar blackness of the satellite doubtless mainly due to projection on the central bright portion of the planet which it traversed being unobstructed by the equatorial belts.

WILLIS L. BARNES.

CHARLESTOWN, Ind.

Time Signals from the U. S. Naval Observatory.—The noon signals sent out daily from the Naval Observatory at Washington will be understood from the following description: The electric connections of the clock are such as to omit certain seconds, as shown by the breaks in the signals. These breaks enable anyone who is listening to a sounder in a telegraph or telephone office to recognize the middle and end of each minute, especially the end of the last minute, when there is a longer interval that is followed by the noon signal. During this last long interval, or 10-second break, those who are in charge of time balls and of clocks that are corrected electrically at noon throw their local lines into circuit so that the noon signal drops the time balls and corrects the clocks.

This series of noon signals is sent continuously over the wires all over the United States for an interval of five minutes immediately preceding noon. For the country east of the Rocky Mountains the signals are sent out by the Observatory at Washington and end at noon of the 75th meridian, standard time, corresponding to 11 A. M. of the 90th meridian and 10 A. M. of the 105th meridian. For the country west of the Rocky Mountains they are sent out by the Observatory at the Mare Island Navy Yard, California, and end at noon of the 120th meridian, the standard time meridian of the Pacific Coast. The transmitting clock that sends out the signals is corrected very accurately, shortly before noon, from the mean of three standard clocks that are rated by star sights with a meridian transit instrument. The noon signal is seldom in error to an amount greater than one or two tenths of a second, although a tenth more may be added by the relays in use on long telegraph lines. Electric transmission over a continuous wire is practically instantaneous. For time signals at other times than

noon, similar signals can be sent out by telegraph or telephone from the same clock that sends out the noon signal.

The above facts are taken from the annual report of the superintendent of the U. S. Naval Observatory for the year ending June 30, 1902. These time signals are not sent out on Sundays nor on holidays.

Since 1876, October 23, Goodsell Observatory of Carleton College has maintained a telegraphic time service chiefly for railway service. The time-signal of Goodsell Observatory differs considerably from that described above. Instead of making the daily signal five minutes long our signal is two minutes in length. Instead of giving it at twelve o'clock, ours is given, daily, at ten o'clock A. M. At the suggestion of some of the general officers of the great railway systems with headquarters in the cities of St. Paul and Minneapolis, both of these changes were made. Formerly our signal was three minutes long; they said shorten the length of the signal and we made it two minutes long. This seems to be satisfactory. The change from 12 o'clock to 10 was made because railway operators must be at their tables at the earlier hour, whereas at 12 o'clock "they are liable to skip for dinner."

Our experience with transmitting clocks is unfavorable. Two astronomical clocks of high grade do all our signal work and they furnish true signals daily to 13,000 miles of railway lines. For some time, years ago, time balls were dropped in Minneapolis and St. Paul at 12 o'clock daily, Northfield time, but this service was discontinued mainly because of the excellent time kept usually by the large clocks on the principal streets by jewelers, and by the fine tower clocks in both cities which are easily seen and read for considerable distances. The time balls were not of much service because people generally would not think to watch for the noon signal given by them if they were busy at the instant. Good clocks upon the streets and in towers are much better for public uses, for they can be consulted any time.

Controlled clocks or mastered clocks are not in favor where constantly accurate time is wanted because they are not reliable. We have discontinued the use of them on this account. By dear experience we know that such clocks need the care of experienced hands in that particular business or they will cause expensive trouble.

The "Triple Cave" in Aquila.—The writer discovered these very interesting dark structures in the Milky Way in Aquila on the 12th of July, 1891, using a Kranz 5-inch photographic doublet. Their discovery was published for the first time at the meeting of the Astronomische Gesellschaft at Munich in 1892. The broadest arm of the dark structure appears as if it were the nearest, and the smallest arm as if it were the furthest from the observer, so that it would seem to give a perspective view into space of the heavens in the Milky Way. But this is probably a mere illusion.

The plate accompanying this note (found in *Knowledge*, September 1902) is a reproduction of part of the original negative made with the worse of the two Brashear 16-inch portrait lenses. The plate taken with the better lens shows a defect in the center of the structure, and is therefore not suitable for reproduction. A bubble in the glass of the negative from which the present reproduction is taken shows itself as a slight defect, but does not interfere with the representation of the dark structure, and the photograph seems therefore good enough for publication.

The broadest of the three "caves" is the most southerly. The co-ordinates of the middle "cave" are—

R. A. $= 19^h\ 33^m$ Decl. $= +\ 10°\ 35'$ (1855.0).

The plates were exposed on July 19, 1901, for three and three-quarters hours. Scale, one degree equals about seven centimeters. DR. MAX WOLF.

Knowledge, September, 1902.